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THE QUARTERLY REVIEW of BIOLOGY

THE GROWTH, GENERAL CHEMISTRY, AND TEMPERATURE RELATIONS OF SALMONID EGGS

By FREDERICK RONALD HAYES
Dalhousie University, Halifax, Nova Scotia

INTRODUCTION

IT IS probable that a greater variety of investigations has been carried out on the egg of the chicken than on any other form. This was inevitable, because the hen's egg is the most familiar of all eggs, is readily obtained, and is easily reared in the laboratory. But among vertebrates, the hen's egg represents a very highly specialized variety. Except for gas exchange, it is isolated from the environment, so that its waste products must be retained within the shell, and the embryo suffers from progressive drying up during development. Thus it is by no means certain that conclusions based on the facts of chick embryology are applicable to vertebrates generally.

A comparison between the hen's egg and the fish egg shows that although both are alike in their possession of an embryo easily detached from the yolk sac, they differ markedly in their relation to their respective environments. The fish egg, during its development, is assured of abundant water from which it can take materials, and it has ample opportunity to get rid of waste products. It can also tolerate the considerable range of temperature exhibited by its environment, in marked contrast to the hen's egg.

The present paper is a general survey of the chemical embryology of salmonid eggs, with an attempt to examine the validity of certain generalizations, when applied to this material. In addition to the chemistry of development, an account is given of the hardening of the egg capsule, which is a special case of the reorganization of a protein molecule to form a keratin-like substance; of the later rupture of the capsule with the aid of enzymes when the larva hatches; of the growth of the embryo and its relation to cell and tissue differentiation, and the effect of temperature on these processes; and of the penetration of oxygen through the capsule, whose permeability may be a limiting factor for the survival of the embryo within.

THE EGG CAPSULE, "WATER HARDENING," AND HATCHING

The relationship of the parts of the salmonid egg system during development are apparent from Fig. 1. The capsule of the egg, also variously called the shell, casing, chorion, vitelline membrane, and egg membrane, is, when shed by the parent fish, weak, fragile, and soluble in dilute alkali (Runnström, 1920; Bogucki, 1930). On transfer to water it becomes a tough, elastic, and insoluble structure, chemically classified as a pseudokeratin (Young and Inman, 1938). Between the capsule and the larva is the aqueous perivitelline or subchorionic space, which appears at the time of fertilization, as a result of the swelling of the egg upon being transferred from ovarian fluid to water. The appearance of the capsule is unchanged until just before hatching, at which time it ruptures, due to the action of the hatching enzyme. Hayes and Armstrong (1942) were unable to find any trend in weight or water content of the capsules during development, the water content remaining at 54 per cent.

1. Changes when the Egg is Laid

The term "water hardening" is used to describe the changes that occur in an egg when it is transferred from coelomic fluid to water. These changes, as Bogucki (1930) and Manery and Irving (1935) have shown, take place in the same way in fertilized and unfertilized eggs. The swelling of a frog's egg on transfer to water is also independent of fertilization (Przylecki, 1917). Measurements of the two

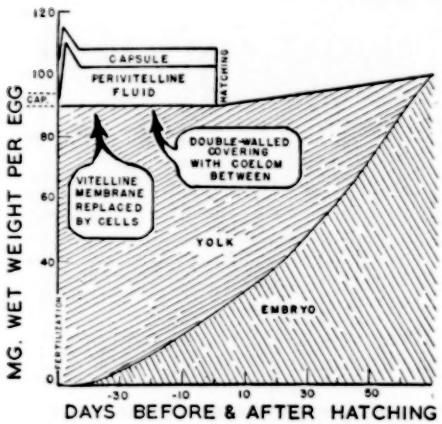

FIG. 1. CHANGING RELATIONSHIPS OF THE CONSTITUENT PARTS OF AN EGG DURING DEVELOPMENT

The term "larva" is used to designate the embryo with yolk sac attached before hatching, as well as after. When the yolk is used up, the little fish is called a fry. Hubbs (1943) has proposed the terms prolarva and postlarva, the latter term corresponding to fry. The larva after hatching is often referred to by fish culturists as an alevin.

In this figure, and in some to follow, hatching is placed at 50 days after fertilization, which is equivalent, approximately, to making an assumption that the development takes place at 10°C. The hatching date is taken as zero, days before and after being given as minus and plus, respectively.

most conspicuous processes, hardening of the capsule and uptake of water, were made by Hayes and Armstrong (1942). The hardening of the capsule was determined by measuring the force necessary to burst an egg, the uptake of water by weighing live eggs at intervals. The dry weight of an egg being found to remain constant, the weight changes are a measure of the water uptake. It was found that the toughening of the capsule does not become marked until some two hours after transfer to water, and that it proceeds at a maximum rate up to about 30 hrs. On the other hand, the uptake of water begins immediately upon transfer and is virtually completed within one hour. Subsequently some of the added water is lost, but by the time the egg is six days old its water content is stabilized at a level that is maintained up to the time of hatching. The visible changes that take place may be summed up in the following scheme:

Egg in coelomic fluid		*Water hardened egg*
Yolk	→	Yolk
	→	Vitelline membrane
		Perivitelline space
Soluble capsule	→	Tough insoluble capsule

Since the egg, when laid, is transferred from ovarian fluid of considerable osmotic pressure to river water, it would be easy to suppose that the water uptake is due to osmosis, but this is not found to be the case. Actually none of the added water appears to find its way into the yolk at all, for it all forms perivitelline fluid. Thus, as Table 1 shows, the increase in egg volume or weight, corresponds quite closely to the quantity of perivitelline fluid. It will be evident that the creation of a previously non-existent space could not be due to an osmotic flow. According to Svetlov (1929), the perivitelline fluid is at all times practically equivalent to river water, having a freezing point depression of less than 0.02°C.

TABLE 1

A Comparison of the Increase in Weight or Volume of the Whole Egg, on Stabilization after Transfer to Water, with the Amount of Perivitelline Fluid as Measured Directly

MATERIAL	INCREASE IN WHOLE EGG AS PERCENTAGE OF ORIGINAL VALUE	PERIVITELLINE FLUID AS PERCENTAGE OF ORIGINAL EGG	AUTHOR
Salmo fontinalis Volume	20	23	Bogucki, 1930
Salmo salar Weight	20	15	Hayes & Armstrong, 1942

The yolk itself appears to be little changed osmotically by the transfer from coelomic fluid. Svetlov (1929) found that in trout yolk the freezing point depression is unchanged through water hardening and up to the time of hatching. Hayes, Darcy, and Sullivan (1946) made analyses of the principal ions in the yolk before and after the egg

was laid. The per cent losses of base amounted to: Na, 10; K, 0; Ca, 8; Mg, 0; a diminution which would lower the osmotic pressure by about 3 per cent. As to chloride, while Hayes, Darcy, and Sullivan found an 8 per cent loss in salmon, Manery and Irving (1935) report that no loss occurs in *Salmo gairdneri* eggs.

It is now necessary to inquire what makes the egg take up water at the time it is laid, why there is little or no salt loss, and what finally stops the swelling. The most plausible explanation to date is that of Bogucki (1930), whose theory is as follows. On transfer to water, the yolk liberates, into the perivitelline space, colloidal substances characterized by the ability to imbibe water. The colloids cannot pass out through the capsule, but water can and does pass in. Hence imbibition is the immediate cause of the formation of the perivitelline fluid. The swelling is specifically inhibited by salt. The process comes to final equilibrium because the hardening of the capsule offers resistance to further swelling. Such an equilibrium is illustrated in Fig. 2, in which it is assumed that the live vitelline membrane is permeable to water but not to salt. The scheme becomes even simpler if the vitelline membrane is also impermeable to water, as Gray (1932) suggests, being supported by the observation of Adler (1932) that dyes which penetrate the capsule will not go on into the yolk. Gray (1920) points out that when an egg dies, however, the covering of the yolk sac does become permeable; there is then a loss of electrolytes to the surrounding water and a subsequent precipitation of the yolk globulins, which are insoluble in tap water. As to the perivitelline fluid, it is opalescent in appearance and clearly positive to Millon's reaction in later stages, although less clearly at the start (Svetlov, 1929). Thus there is evidence, though not conclusive, of the presence of protein here. The known properties of the egg capsule, as determined by Bogucki and Svetlov, also fit in quite well with the theory. In addition to its obvious permeability to water in early stages, the egg capsule transmits salts and simple organic molecules such as urea, glucose, and amino acids, and also such dyes as neutral red and eosin. It is practically impermeable to colloids such as starch, egg albumen, etc.

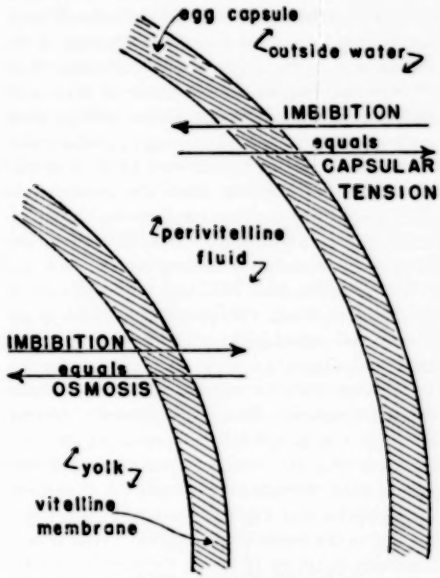

FIG. 2. A DIAGRAM SUGGESTING THE MECHANISM THAT BRINGS ABOUT WATER EQUILIBRIUM A FEW DAYS AFTER THE EGGS ARE LAID, THAT IS, ARE TRANSFERRED FROM COELOMIC FLUID TO WATER

Runnström (1920) has observed that the swelling of the egg is inhibited by sea water dilutions in direct proportion to their osmotic pressure, until at the point of isotonicity there is no swelling. He has further shown that solutions of single salts, as well as Ringer's solution, inhibit swelling. On the other hand, Bogucki finds that the swelling is not inhibited even in hypertonic solutions of glucose or urea. The discrepancy between the action of the two classes of solution is not clear at present; it might be due to different permeability rates or to the action of specific salt ions such as calcium, as is indicated by results of Manery and Fisher (unpublished).

II. Softening of the Capsule and Hatching

The strength of the capsule is most easily measured by determining the crushing force necessary to burst the egg. This was done at intervals for trout and salmon eggs, the results being shown in Fig. 3. It is seen that salmon eggs, after water hardening, remain at their maximum resistance to pressure until some 20–30 days before hatching after which they begin to soften. At about 10 days the rate of softening is lessened, and the curve tends to flatten, the process, however, being somewhat obscured by the fact that in some of the eggs used, the hatching enzyme (see below) had begun

to work. Such eggs would give a reading of 0.0 and when averaged with the others would pull down the points at the right side of Fig. 3. If the 0.0 readings are struck out and a new average taken, it is found that the curve becomes quite flat.

Remotti (1925) carried out a variant of the above experiment on muraenid eggs and obtained a decline like those in Fig. 3. He was not able to do the initial part of the curve, since his material was collected in various stages from the plankton of the Strait of Messina.

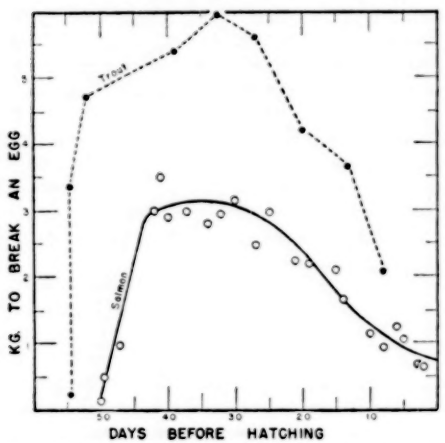

FIG. 3. VARIATION DURING DEVELOPMENT IN THE STRENGTH OF THE EGG CAPSULE

The values represent the force necessary to crush an egg. Trout from Hein (1907); salmon from Hayes (1942).

What is the cause of the softening that begins halfway to hatching? It cannot be due to the hatching enzyme, for, as will be shown below, this appears only in the hours just before hatching. Remotti suggested physical stretching by inside pressure, and drew attention to the fact that proteins are known to undergo molecular rearrangement when stretched, a theory made plausible by numerous x-ray studies of protein structure. Alternatively, one might postulate a softening enzyme that appears earlier than the hatching enzyme proper. Conclusive evidence on the matter is lacking.

All the evidence goes to show that the softening reported by Hein (1907) is not normally sufficient to permit the egg to hatch. (A precocious extension of the process is a well known "disease" in hatcheries, leading to premature bursting and invariable death of eggs.) The mechanism of hatching was described by Wintrebert (1912), working on rainbow trout. He showed that the enzyme appears only a few hours before hatching. He described ectodermal glands near the gills which are said to secrete the enzyme into the perivitelline fluid, and proved by experiments with narcotics that embryonic movements are not necessary for the hatching process. He also observed that the hatching enzyme destroys the capsules of unfertilized trout eggs just as quickly as those of embryos ready to hatch. Bourdin (1926) extended Wintrebert's work by making a histological study of the glands, and by the study of pH and temperature effects on the enzyme. The chemistry of the process was further investigated by Hayes (1942), whose method was to remove salmon egg capsules before the softening had set in, and store them. A droplet of buffered perivitelline fluid was placed in a half-capsule, and the time for digestion noted.

The optimum temperature and pH for the action of the enzyme are given respectively as: 14°C and 7.2 by Bourdin; and 20°C and 9.6 by Hayes. In the rainbow trout, the perivitelline fluid is approximately neutral (Bourdin), but in the brook trout and salmon it is quite acid (pH 4.6, Hayes). In the latter cases one wonders how the enzyme can digest the capsule efficiently. It appears, however, from tests with intact larvae removed from the capsules, that the secretion from the ectodermal cells is quite strongly alkaline, pH 8.8. It is therefore probable that wherever the ectoderm is closely applied to the inside of the capsule a local zone of alkalinity is set up in which the enzyme can act. Meanwhile, as the enzyme is produced, the movements of the larva distribute it throughout the whole of the perivitelline fluid.

The action of most proteolytic enzymes, such as trypsin and pepsin, is by hydrolysis. Such enzymes, however, were found to have no effect at all on the capsule. (Young and Inman in 1938 did report a slight effect of pepsin, but none with trypsin.) It appeared desirable to see whether the action of the hatching enzyme is hydrolytic. The method used was to measure the quantity of primary amino nitrogen in perivitelline fluid as hatching time approached (Hayes, 1942). No clear increase could be found. In another test, capsules were placed in a test tube with active fluid, suitably buffered, and the NH_2 groups were estimated as

digestion proceeded. It was found that only about 6 per cent of the nitrogen in a capsule was hydrolyzed. This might be compared with a typical trypsin action in which the value approaches 100 per cent, or a pepsin digestion of 25 per cent. Evidently the action of the hatching enzyme is hardly comparable to that of trypsin or pepsin. In fact, it is not necessary to assume that hydrolysis occurs at all in the main capsular protein, because there is usually present in any protein a small quantity of NH_2 nitrogen which would be liberated when the capsule was broken up. Besides pseudokeratin, there may also be in the capsule small quantities of other proteins which could undergo hydrolysis.

In addition to fish egg capsules, conspicuous examples of the digestion of scleroprotein are furnished by certain insects, e.g., the clothes moth, *Tineola*, which has been studied by Linderstrøm-Lang and Duspiva (1935). They found that, while digestion occurs in the gut with optimum action at pH 9.3, the proteinase when removed from the gut and mixed with sheep wool produces no digestion. If a reducing agent is added to the test-tube preparation, the wool is dissolved by it through the splitting of peptide linkages, and the proteinase will act. Thus the keratinase system of the moth is made up of a proteinase and a reducing agent. Applying this reasoning to the salmon, we might dispense with the proteinase altogether and postulate the presence of a reducing agent only, which would liquefy the capsule. This speculation has not yet been tested experimentally.

EMBRYONIC GROWTH

I. General Remarks on Growth

If one measures the weight or length of a growing organism at various intervals of time, any two determinations differ by amounts somehow related to the time that has elapsed between them. If the time is plotted on the abscissa and the weight or length on the ordinate, the resultant curve is often more or less S-shaped (Fig. 4A). Sachs (1874) called the data described by the curve, a growth cycle or great period of growth. Although, mathematically, a growth cycle extends to infinity, in practice it often has a more or less clearly marked end, e.g., at the onset of a second cycle or the withering of a plant. It is with reference to such an end that such expressions as "center of a cycle" are often used.

Some of the properties implicit in an S-curve can be brought into view by changing it around to show absolute growth rate (Fig. 4B), which answers the question "How much is added per unit time to what is already there?"

$$AGR = \frac{w_1 - w_0}{t_1 - t_0} \qquad (1)$$

approximately, where w_0 is the weight at any time, t_0 and w_1 is the weight at a slightly later time, t_1.

In 1891, Minot suggested that the growth rate

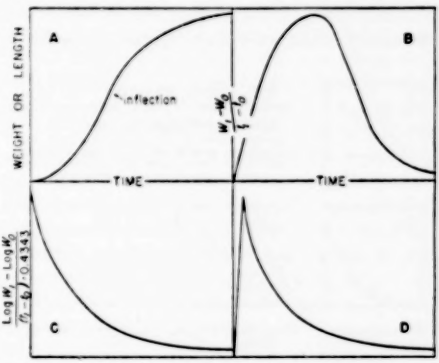

FIG. 4. A GROWTH CYCLE AND ITS DERIVATIVES
A. Complete cycle of Sachs. B. Absolute growth rate. C. Usual relative growth rate or Minot curve. D. Occasional RGR as in a few plants.

should be expressed in terms of the material already there by use of the formula,

$$\text{Percentage growth rate (Minot)} = \frac{100(w_1 - w_0)}{w_0(t_1 - t_0)} \qquad (2)$$

D'Arcy Thompson pointed out in 1917 that Minot's formula was tantamount to plotting $\frac{dw}{w.dt}$ and Schmalhausen (1926, 1927, 1931) and Brody (1927) have independently shown that the Minot equation tends to give results that are too high in the youngest stages, and have proposed to substitute for it

$$\text{Relative Growth Rate} = \underset{\text{(Schmalhausen)}}{C_v} = \underset{\text{(Brody)}}{k_1} = \frac{dw}{w \cdot dt}$$

$$= \frac{\log w_1 - \log w_0}{(t_1 - t_0) \cdot 0.4343} \qquad (3)$$

C_r (or Brody's k_1) may be considered a better version of $\frac{\text{Minot}}{100}$. There has been a tendency to exaggerate the shortcomings of Minot's way of looking at growth, and it is well to remember that his conclusions would have been unchanged even if he had used the C_r formula.

Fig. 4, C and D show typical relative growth rate or Minot curves. In a few plants the curve may have the same form and properties as the absolute growth rate curve, but the peak is far to the left (Fig. 4D). An example is found in Silberschmidt's (1928) work on the growth of the oat at 4°C. Such curves are special cases, for in nearly all plants, and probably in all animals, the curve starts at a maximum and falls continuously, approaching the time axis asymptotically (Fig. 4C).

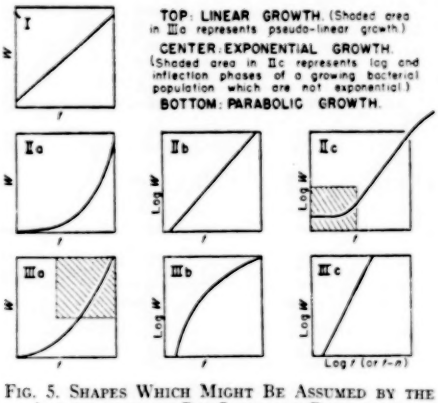

FIG. 5. SHAPES WHICH MIGHT BE ASSUMED BY THE ACCELERATING OR PRE-INFECTION PHASE OF A SACHS GROWTH CYCLE

Since the Sachs curve is of such wide application, numerous proposals have been made to fit it, or a derivative of it, by an algebraic formula. The embryologist is fortunate in finding that his material usually corresponds only to that part of a Sachs curve to the left of the inflection, which means that he has to deal only with the accelerating phase of a growth cycle. This gives him two very considerable advantages over other students of growth: (1) algebraic expressions to fit his results may have only two arbitrary constants; (2) the observer is often able to force his raw data into a straight line graph.

It will be useful to consider three common forms of the accelerating phase of a Sachs curve, as illustrated in Fig. 5, in which w represents weight, volume, or length, and t represents time. The top left curve shows a straight line slope between t and w and is described by the formula

$$w = k_0 + k_1 t \qquad (4)$$

where k_0 is the intercept of the line with the w axis, and k_1 the slope of the line. This kind of curve often appears in plots of length versus time as in the salmon (see below). In some embryos (but not in the salmon), the weight is found to increase in proportion to some power of the length such as the cube. If this should happen when the length curve looks like Fig. 5, I, then the weight curve will look like Fig. 5, IIa.

Weight or volume plotted against time sometimes gives a straight line. This may be genuine as in I, or may be merely indistinguishable from the shaded portion of IIIa, which shows how a parabola gets less curved as it goes up. Data taken over a relatively short interval corresponding to the zone of a Sachs curve near the inflection are seldom reliable enough to distinguish between I and the shaded part of IIIa.

If an observer finds, as in Fig. 5, IIb, that log w versus t gives a straight line, then

$$\log w = k_0 + k_1 t \qquad (5)$$

and the Sachs curve describes exponential growth as in IIa. For brief intervals, the growth of a salmon embryo can be regarded as approximately exponential (Hayes and Armstrong, 1943), and Brody has reported that exponential growth occurs for several days at a stretch in the chick embryo, though others, including MacDowell, Allen, and MacDowell (1927), have been skeptical of his conclusions. In the metazoon body as a whole, pure exponential growth is never observed for very long.

A third possibility, and the one most usually met with in embryo weights, is for the plot of log w versus log t to give a straight line, as in Fig. 5, IIIc. This means that the inflected part of the original Sachs curve, IIIa, is a parabola of the type

$$w = k_0 t^{k_1} \qquad (6)$$

Parabolic growth in weight for the human embryo was suggested by Friedenthal in 1914, and its general validity has been noted by Murray (1925), Schmalhausen, and others. The modification

$$\log w = k_0 + k_1 \log(t - n) \qquad (7)$$

proposed by MacDowell, Allen, and MacDowell (1927) is generally used today, where n is the time from fertilization to the establishment of the embryonic axis. The theory is that before n days, when there is an undifferentiated mass of cells spreading over the yolk sac, the rules of growth will not be the same as later, when the observer is dealing with the embryo proper. Hence time should be reckoned from the establishment of the permanent plan. While n is of course a new constant, it is a natural one, directly observable in the material, to whose use no objection can be taken. The MacDowell formula has been successfully applied, by a proper choice of n, to a considerable variety of embryonic data.

In Fig. 5, IIIb there is shown the plot of log w versus t corresponding to IIIc, being a curve tending to flatten as time goes on. When the slope of IIIb, which Schmalhausen called C_v, is plotted against time, an *RGR* or Minot curve results. Thus IIIb and a Minot curve are different ways of saying the same thing, with nothing essential to choose between them. Minot's method is pictorially more satisfying, since he uses a dropping line to describe a decrease.

In cases, like Fig. 5, IIIc, where the function is a straight line, it follows that

$$C_v \cdot t = K; \text{ or } C_v(t - n) = K \qquad (8)$$

with K defined by Schmalhausen as a "growth constant," whose value is often of the order of 2 or 3.

The phenomena of growth which have just been considered, together with Minot's idea of progressive differentiation, have led Schmalhausen to propose the "law of parabolic growth." This "law" states that embryonic growth curves often look like Fig. 5, IIIa, and the proposed explanation is as follows. Undifferentiated protoplasm grows (under constant conditions) with constant specific velocity, i.e., exponentially. At the beginning, all the protoplasm is undifferentiated and growth is exponential, but with time a certain proportion of the original protoplasm becomes transformed into differentiated material. The products of differentiation do not themselves assimilate material, but increase rather with the aid of materials contributed to them by the transformation of undifferentiated protoplasm. Thus they are only produced and added to at the cost of the latter. It follows that the proportion of undifferentiated protoplasm in the organism decreases steadily with development. The growth of the organism (or tissue, etc.) is a compromise between the exponential growth of one part and zero growth of the other. Such a compromise results in a parabola. Although Schmalhausen's "law" has been criticized, notably by Ludwig (1929), and although it lacks adequate proof, it nevertheless provides a simple, over-all account of the accelerating phase of a growth cycle, and there is no rival theory resting on any firmer ground.

For the sake of completeness another important growth possibility, illustrated in Fig. 5, IIc, may be mentioned. This is the well-known curve of growth of a bacterial population. When log w is plotted against t there is at first a lag phase with little cell division, followed by an inflection which could represent (1) exponential growth in numbers of the cells that have already begun to divide, plus (2) additional cells of the inoculum completing their lag phase and undergoing active division. Alternatively, the inflection could represent an increase in the rate of cell division as the lag phase is passed. After the inflection, exponential growth follows just as in IIb. If the bacterial growth curve, IIc, were continued on from the upper right hand corner, its course would continue as a parabola similar to IIIb.

II. Growth Curve of Salmonids

The trout, according to Wood (1932), and the salmon, according to Hayes and Armstrong (1943), have a growth curve which, up to the end of yolk absorption, is like the part of Fig. 4A before the inflection (i.e., the peak of the absolute growth curve (Fig. 4B) is not reached.) This is not to deny that when the yolk is all gone, or nearly all gone, the embryo, owing to starvation, will necessarily stop growing. Gray (1928), whose curve is reproduced in Fig. 6, and Kronfeld and Scheminzky (1926) (for the trout) as well as Privolniev (1935) (for the salmon) have reported a decline in *AGR* before the yolk is quite gone. Differences may be in part due to the difficulty in deciding when the yolk is entirely used up, for there is still some left when the external sac has disappeared. If the reported decline in *AGR* could be abolished by feeding, the idea of a complete growth cycle could fairly be abandoned. This experiment has been done with trout by Willer (1929). He weighed whole larvae, hence his values represent embryo gain minus yolk loss, which would tend, if anything, to produce the effect of a decline after

hatching, even if none existed for the embryo. Feeding was begun, in conformity to hatchery practice, when the yolk sac was partly absorbed, and there was in fact no sign of a decline in growth up to the time the fry were ready for planting, two months after the yolk sac had completely disappeared.

In Fig. 7 the wet weights of salmon embryos have been plotted on logarithmic paper. Time is

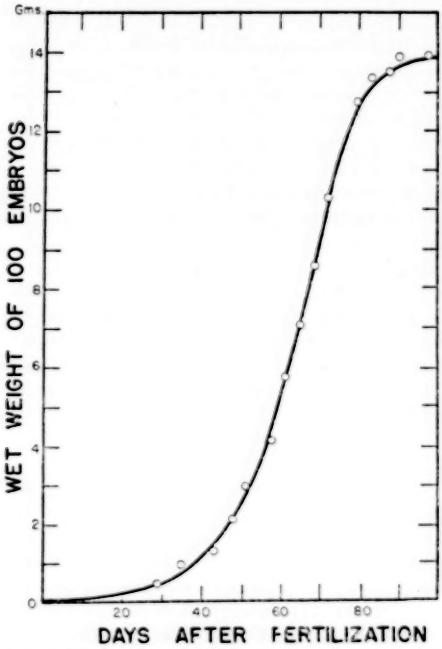

FIG. 6. GROWTH OF THE TROUT, SALMO FARIO, AT 10°C
From Gray (1928)

reckoned from 9 days after fertilization, which was the date of establishment of the embryonic axis under the temperature conditions. The points are fitted by one straight line, which means that the data have been smoothed in accordance with the MacDowell formula (7).

III. Relative Growth Rate

If C_e be plotted against time, a Minot curve results. Privolniev (1935) reports that the Minot curve for the salmon is like Fig. 4D, but Hayes and Armstrong disagreed, finding an *RGR* curve like Fig. 4C. For the interval after hatching, there are several published sets of weights, which have been assessed by Hayes and Armstrong (1943). The question is whether there is a hump on the Minot curve after hatching (and therefore whether the fish embryo differs from warm-blooded embryos in its habits of growth). The majority answer is certainly in the negative, the only positive result being that of Wood (1932) for trout eggs reared at high temperatures. Obviously

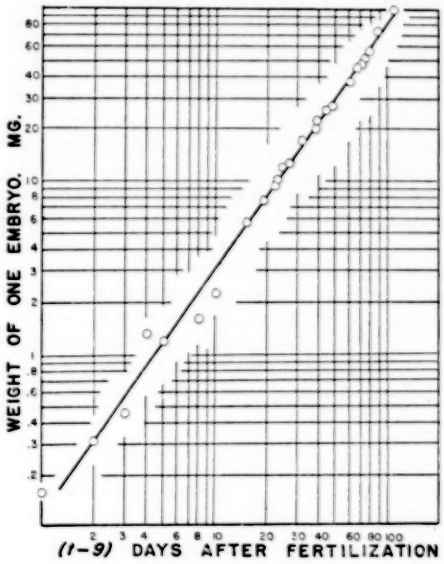

FIG. 7. SALMON WET WEIGHTS PLOTTED AGAINST TIME ON A LOGARITHMIC SCALE, WITH TIME BEING RECKONED FROM THE ESTABLISHMENT OF THE EMBRYONIC AXIS, NINE DAYS AFTER FERTILIZATION
From Hayes & Armstrong (1942)

the effect of temperature on the shape of the growth rate curve deserves further investigation.

It may be noted that deviations from the smoothed curve of Fig. 4C, even if valid, would not contradict the general soundness of the MacDowell method. Such deviations bear to it the same relation that mountain heights and ocean depths do to the general roundness of the world.

IV. Errors in Growth Rate Curves

Anyone who has constructed a growth rate curve will have noted the great scattering of points, so that for an accurate representation of the facts there have to be many closely spaced

observations. The cause of scattering lies in the arithmetic, for it will be noticed that in calculating the absolute growth rate (and the same reasoning would apply to the relative growth rate)

$$AGR = \frac{\text{large weight minus slightly smaller weight}}{\text{large time minus slightly smaller time}}$$

There are two chief sources of error here. First, the numerator shows errors in weight estimations, which are relatively greater in younger stages when the embryos are very small; second, errors arise from the fact that even under identical conditions development does not proceed for all embryos at the same rate, which is equivalent to an error in the times given in the denominator. Thus the calculation of a growth rate causes figures with small errors to be changed into a figure with a much larger error. Some caution is accordingly necessary in the matter of placing physiological interpretations on the scattering of growth rate points, as Privolniev (1935) has done. (Variations in the temperature quotient, Q_{10}, are also great and have sometimes been subjected to over-detailed interpretation, e.g., by Ljubitzky (1935), as mentioned below).

V. Growth in Length

Lengths of trout embryos have been measured by Willer (1929) under hatchery conditions, with feeding begun at the usual time, while Allen (1932) has published a good series on the salmon, which was not fed. Both found a complete growth cycle, like Fig. 4A, with the inflection, in the case of the salmon, only 10 days after hatching. When length is plotted against time in Allen's curve, the portion before the inflection is a straight line, so that

$$l = a + bt \tag{9}$$

Nevertheless the MacDowell formula will fit, hence

$$\frac{d \log l}{d \log (t - 9)} = 1 \tag{10}$$

With an abrupt change in slope the MacDowell equation also fits approximately the post-inflection part of the curve, except for the final points, where growth had practically stopped. The inflection occurs long before the already discussed starvation inflection in weight, which some workers have described. Several conclusions may be drawn.

(1) No simple mathematical relation can exist between length and weight for the whole period of development, as Schmalhausen has suggested for some embryos. However, for the interval before the length inflection, the relation

$$w = l^n$$

might hold.

(2) Formulae such as that put forward by Backman (1931, 1932), purporting to describe either weight or length curves with equal ease, cannot be used for a description of both processes in the same period of salmonid development. (Backman also uses area as an alternative unit).

(3) Growth cycles in the sense of Sachs may be less general than is commonly thought, since a demonstration of their existence in terms of one unit does not constitute evidence about some other unit.

VI. Effect of Egg Size on Growth

Hayes and Armstrong (1942) compared the growth of embryos from salmon eggs weighing 108.5 mg. with that of embryos from eggs weighing 79 mg. It was found that the small-egg embryos, though smaller to start with, grew more rapidly than the large-egg embryos. These results show that although the grilse embryo is smaller than the salmon embryo at the beginning of development, by 35 days after hatching it is approximately the same size as the salmon. It is reasonable to assume that the initial smallness of the grilse embryo is related to egg size. A possible explanation is that there is a smaller amount of protoplasm at the beginning of development and that, therefore, the embryo formed is smaller. Little is known about the method of absorption of materials from the yolk sac, but it may be that in the early stages it bears some relation to the surface of the embryo on the yolk sac. Therefore, one might say that it is not until the development of the vitelline circulation that the grilse embryo is in a position to withdraw the maximum amount of yolk sac material. Then, although there is much more yolk in the yolk sac of the salmon, the grilse embryo begins to catch up to the salmon.

A general phenomenon observable in all forms is the characteristic species size. Marked differences in the young do not prevent them from approaching the adult size of their species. No one would suppose that a grilse embryo would in five years be very different in size from any other five-year salmon. The interesting thing about this investiga-

tion is that the tendency shows itself in the salmon at such an early age. It is undoubtedly true that a grilse embryo will have used up its supply of yolk before the salmon embryo, but it is then quite capable of utilizing external food. The salmon embryo will, however, be larger before it has to search for external food and may therefore have a greater chance of surviving.

Byerly (1932) has found that in the chick there is no demonstrable difference in growth rates of embryos from eggs of different sizes between the 3rd and 18th days. After the 18th day the rates diverge, owing to lack of food in the small eggs. There are some obvious differences in the development of the salmon and chick. The former hatches while still in the yolk sac stage and is able to take up water from its environment, but the chick must be supplied with sufficient water to last until hatching, which takes place at a much later morphological stage. Moreover, a salmon, although provided with relatively little yolk, is a free-swimming form able to seek external food long before the yolk sac has disappeared. In the chick, on the other hand, the smallness of the yolk will be felt in the days before hatching.

Dry weights of salmon and grilse embryos were also observed, and it was found that the rate of increase of dry material showed no significant difference in the two cases. Thus, wet growth of grilse is greater than that of salmon; dry growth rates are not significantly different; therefore the extra growth rate of the grilse is due to water uptake.

GENERAL CHEMISTRY OF DEVELOPMENT

The purpose of this section is to discuss the energy sources of the developing embryo, and the chemical transformations which occur during the utilization of the yolk. It will be convenient to deal with the main classes of food-stuff in turn.

1. Carbohydrate

It has been known for many years that the albumen of hens' eggs contains some carbohydrate attached to protein, but as for the yolk, earlier analyses for carbohydrate-protein complexes were generally negative. However, according to Needham (1942, p. 16), protein-bound carbohydrate has now been isolated in chick yolk. There is so far no evidence for a bound carbohydrate fraction in fish eggs, and in the discussion which follows, no allowance is made for the possible presence of such a complex in salmon egg yolk. If salmon yolk resembled chick yolk with respect to protein-bound carbohydrate, the expected amount of the latter would be of the order of 0.02 mg. per egg, a negligible store.

Hayes and Hollett (1940) made analyses of glucose and glycogen in salmon eggs from fertilization until the yolk sac had completely disappeared. They found no glycogen in early stages. However, Daniel (1947), using more sensitive tests reinforced by cytological examination, has reported that some 0.04 mg. of glycogen is present in the egg from the start. Accepting Daniel's figures for early glycogen, the results are given in Figs. 8 and 9. The trend is clearly for an increase in carbohydrate from fertilization up to nearly the end of

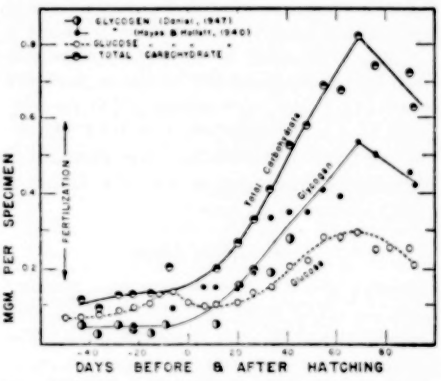

FIG. 8. DISTRIBUTION OF CARBOHYDRATE IN THE SALMON LARVA

the yolk sac period. Glucose temporarily diminishes around the hatching period, but no corresponding decrease of glycogen was evident. Fig. 8 indicates that the mechanism for building up glucose is present from the beginning, since its increase is observed only a few days after fertilization.

Periodic determinations of the amount of glucose present in separated embryos and yolks showed that the concentrations in the two parts tend to rise and fall together. The explanation may be that glucose in an embryo, as elsewhere, is not stored in any specific tissue, but passes freely through all walls and is distributed throughout the larval system as an aqueous solution equally concentrated in all parts. The ratio of glucose between embryo and yolk at any time would therefore serve merely as an index of the relative quantities of water in each. Thus the embryo, with 80 to 90 per cent

water, will contain more glucose per gram wet weight than the yolk, with 50 to 60 per cent water. When the glucose concentration is expressed in terms of water, it is found that when the egg is laid there is about 0.1 g. of glucose per 100 g. water, an amount which rises to 0.14 per cent at hatching and thence to 0.28 per cent by the time the yolk is used up.

Fig. 8 shows that the synthesis of glucose begins at the time of fertilization. The source can hardly be glycogen, since there is no corresponding loss of this substance. It is presumably accomplished by means of enzymes within the embryonic cells and will therefore be proportional in intensity to the number of such cells. This synthesis of glucose evidently never stops during development (for total carbohydrate continually increases), although it is quite possible that its rate diminishes for a short time before hatching. Against a continual synthesis we have to set (a) the utilization of glucose as fuel, which undoubtedly goes on all the time, although we cannot express it quantitatively, and (b) the removal of glucose as glycogen. The capacity for glycogen formation is not present from the beginning. According to Hayes and Hollett, glycogen synthesis begins three weeks or more before hatching; according to Daniel, not until some days after hatching. Histochemical studies by Daniel have shown that glycogen is initially present in the perivitelline fluid and blastoderm cells, especially those nearest the capsule, although not in the main yolk mass.

In the liver, only minute quantities of reducing sugar were found. As to glycogen, Daniel, by staining reactions, has detected it from the formation of the liver, indicating that a glycogenic function is present from the start. Glycogen was also observed by Daniel in muscle cells even before striations appeared. It is clear from Fig. 9 that by the end of the yolk sac period the liver is a major site of glycogen storage.

A search of the literature reveals no other case in which the embryo ends up with more carbohydrate than the egg had at the beginning. This unique property of the salmon egg is no doubt shared by other teleosts. We do not know what the source of this new carbohydrate is. Certainly the great period of carbohydrate synthesis after hatching corresponds to a sharp drop in fat and protein (see below), although the carbohydrate gain is so small that the two cannot be said to be quantitatively related.

A synthesis of glycogen (as distinct from total carbohydrate) is found in the chick as well as in the salmon (Needham, 1927). In the salmon the glycogen is all in the embryo. In the chick, however, Needham had divided the system into "embryo" and "remainder of the egg." In the latter part he included not only the yolk and albumen, but the allantois, amnion, and the coelom with its two walls, each composed of two germ layers. It is not surprising, therefore, that the newly formed glycogen was found in both parts. There is no evidence for storage of glycogen in the yolk or albumen of the chick. It may be noted that Daniel divided the salmon egg as Needham did the chick, counting the yolk sac envelopes with the yolk. Glycogen was observed in both fractions.

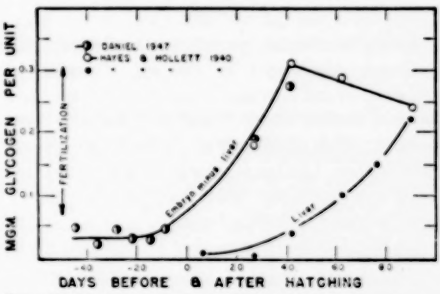

FIG. 9. DISTRIBUTION OF GLYCOGEN BETWEEN THE LIVER AND THE REST OF THE SALMON EMBRYO

There are however, no "extra-embryonic" membranes in the salmon which are shed in later development, and for this reason Hayes and Hollett divided the egg on the basis of cells vs. noncellular yolk. They found no glycogen in the yolk proper at any time.

The view has been expressed that glucose traverses cell walls and is found everywhere in the salmon system, including the yolk. Glycogen, on the other hand, is evidently confined to cells. It is interesting to observe that the eggs of birds, reptiles, and fishes have their initial store as glucose, with little or no glycogen. Amphibia and invertebrates, on the contrary, have stores of glycogen with little or no glucose. (See table in Needham, 1931, p. 278).

If we look for an underlying morphological explanation, we find that the "glycogen" eggs are those in which the whole egg divides into cells that participate in development. In the frog, for instance, though the cells in early development differ markedly as to size, each cell will contain a

store of glycogen. One does not think of the embryo as taking material from the yolk, but rather of the yolk cells continuing to divide and changing gradually into differentiated embryonic cells. The stores are therefore divided from the outset, yolk platelets being present, for instance, in the embryonic muscle cells of *Amblystoma*.

Turning to the "glucose" eggs of birds, reptiles, and teleosts, it is found that the embryonic stores are locked away in the large, non-cellular yolk sac. As the small embryo uses up glucose, it is replaced by simple diffusion from the yolk, a mechanism that would not serve if glycogen made up the carbohydrate store. The glucose taken by the embryo is constantly replaced and augmented, although we do not know where or how.

II. Protein

Aside from water, protein is at all times the dominant constituent of the egg. Changes in protein (or total nitrogen) in the system have been followed several times (Tangl and Farkas, 1904; Gortner, 1913; Hayes, 1930; Hollett and Hayes, 1946). There has been general failure to demonstrate any diminution before hatching, but shortly after hatching a decline begins.

While all workers agree that a large amount of protein is used up for energy, the precise proportion reported is subject to variation, depending on whether the experiments (a) ended before all the yolk had gone, or (b) continued into the starvation period. From the following list it appears that the true value for protein used up at the completion of the yolk-sac stage lies in the vicinity of 40 per cent of the original protein store.

SPECIES	PER CENT	REFERENCES
Salvelinus fontinalis	21.9	Gortner (1913)
Salmo irideus	49.3	Smith (1942)
Salmo salar	36.3	Hayes (1930)
Salmo salar	44.6	Hollett and Hayes (1946)

Hollett and Hayes, by dissecting the larva before analysis, were able to compare the embryo gain with yolk loss, the difference between the two representing combustion. If the gain and loss per day are brought to a common base, say per 100 g. of embryo, a rate curve can be constructed, which answers the question: what per cent of its dry weight does the embryo absorb (yolk loss) or store (gain) per day? Such a curve, seen in Fig. 10 is very useful, for by it one may compare widely differing sizes and species of embryos. As the dry embryo is some four-fifths protein, it is apparent that "protein," for this curve, is pretty nearly a synonym for "dry weight." Hence in Fig. 10 we plot essentially $\frac{dw}{w.dt}$ against t, which gives a Minot or relative growth rate curve, as in Fig. 4C, so that it is not surprising to find that Fig. 10 exhibits the decline to whose general nature Minot drew attention. It is also obvious that, since protein is being used up and no food supplied, the yolk loss will be greater than the embryo gain. What could not be predicted is that the curves, once established, remain parallel. The distance between the two lines is the rate of combustion, and it is quite clear

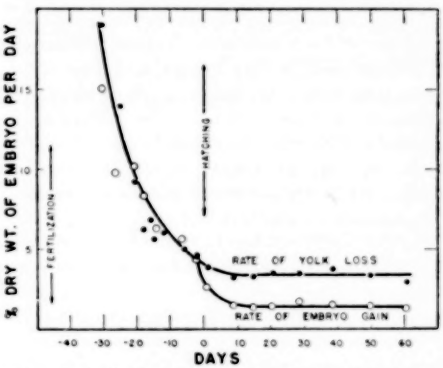

FIG. 10. A COMPARISON OF THE RATE OF PROTEIN ABSORPTION FROM THE YOLK WITH THE RATE OF STORAGE BY THE SALMON EMBRYO

Compare with Fig. 11, which gives similar values for fat. From Hollett and Hayes (1946).

that no peak exists, which means that the larvae, in spite of marked increases in swimming as the yolk sac gets small, do not take protein for their extra activity. There is, however, a post-hatching combustion peak for fat (see below). On the other hand, carbohydrate, or at any rate free carbohydrate, as already noted, undergoes a steady increase in quantity during development.

As regards non-protein nitrogen, Hollett and Hayes reported a steady increase throughout development, a relation which means either that excretory products are appearing faster than they are being carried away, or that free amino acids are appearing. The salmon in this respect differs from chick, in which there is, after the fifth day of development, a steady fall in the ratio of non-protein nitrogen to protein (Needham, 1931, p.

1074). Hollett and Hayes found that the new non-protein was in the embryo rather than the yolk, for the former exhibited a marked increase after hatching.

III. Fat

The total fat of the salmon embryonic system was investigated by Miescher (1866), Hayes (1930), and Hayes and Ross (1936). It now appears that until the fourth week after hatching no major variations in fat can be observed. Then it begins to disappear quite rapidly, some 75 per cent being consumed to provide energy for the developing embryo.

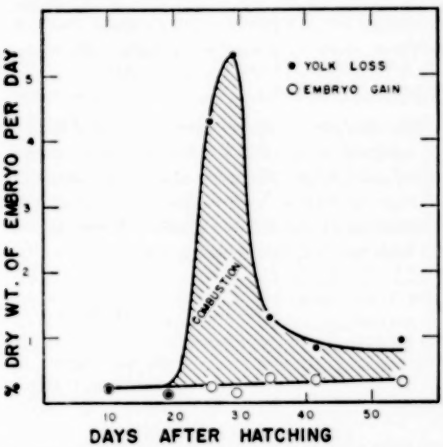

FIG. 11. A COMPARISON OF THE RATE OF FAT ABSORPTION FROM THE SALMON YOLK WITH THE RATE OF STORAGE BY THE EMBRYO

Compare with Fig. 10, which gives similar values for protein. From Hayes and Ross (1936), omitting their pre-hatching part.

In early embryos there is some 3.5 per cent of fat, the amount increasing gradually to 14 per cent by the end of yolk absorption. Pelluet (1944) has observed a storage of fat, which can be seen after hatching in the mesentery supporting the gut. The embryonic storage of fat is interrupted at the time of hatching, an example of the general stoppage at this time, discussed below.

The sum of the fat used up in combustion plus fat stored by the embryo is defined as fat absorbed by the embryo from the yolk sac. This quantity measures the movement of fat into the embryo. When daily increments of fat absorbed and stored have been calculated, they may be related to embryonic weights so as to give the rates of these respective processes. That is, we can know what percentage of its dry weight the embryo absorbs, stores, and burns every day. The values are given in Fig. 11, except for those of the pre-hatching period, which have been omitted as unreliable. The values have been recalculated on the basis of better embryonic weights than were available when the original paper was written. The figure shows a clear absorption peak for fat, which comes in quite suddenly as an energy source. Storage by the embryo, on the other hand, shows no great fluctuation in rate. Evidently the rates for combustion and storage are not related. Fig. 11 is essentially a Minot curve, $\frac{dw}{w.dt}$ versus t, and can be conveniently compared with the corresponding curve for protein (Fig. 10) and with that for the general embryo (Fig. 4C).

IV. Energy sources Before Hatching

Direct analyses have failed to demonstrate any clear pre-hatching diminution in the dry weight, fat, or protein of an egg. It must therefore be concluded that owing to normal weight variations from egg to egg, materials used up fall within the limits of experimental error when attempts are made to measure them directly. Indirectly, however, the probable loss in dry weight before hatching can be estimated from the oxygen consumption, by assuming the general relationship in which 1 g. of protein corresponds to 0.95 liters of oxygen; of fat, to 2.02 liters; and of carbohydrate, to 0.81 liters. Carbohydrate need not be further considered, since it is a small fraction of the egg and increases during development. Privolniev (1938) measured the oxygen consumption of salmon eggs at intervals. When his values are summed and a temperature correction is applied, it appears that a single egg should use up about 1 mg. of fat, or 2 mg. of protein, or some combination thereof, by the time it hatches. Trout respiration measurements by Schlenk (1933), adjusted for weight, give lower values. These quantities represent one-tenth or less of the fat or protein present at the start.

Of the two, fat appears to be a more likely pre-hatching energy source for the following reasons:

1. Measurements of the respiratory quotient, made by Schlenk on trout eggs, indicate fat utilization—in fact are too low even for pure fat. Amber-

son and Armstrong (1933) report similar low R. Q.'s for *Fundulus* eggs.

2. The loss of weight, considered as fat, is minimal, and therefore most easily concealed in experimental error.

3. It is unlikely that the necessary protein could have been consumed without being discovered. Moreover, if protein were the main source of energy before hatching, 1 to 2 mg. would have to be used up, which would give rise to 0.2 or more mg. of non-protein nitrogen, a quantity that might be held inside the capsule. The observed rise in non-protein nitrogen, however (Hollett and Hayes, 1946) is only 0.02 mg., or less than one-tenth of the above, a fact that adds support to the idea that protein is not a main energy source before hatching. It must also be noted that Gortner (1913) was unable to find any perceptible accumulation of nitrogenous end products in the prehatching phase of trout development.

V. Energy Sources After Hatching

A salmon egg at the start contains 9.4 mg. of fat; by the time the yolk is used up the embryo has 2.2 mg. left. The difference of 7.2 mg. is fat consumed. From the usual relation of 9.45 cal. per mg., it is found that fat contributes 68 cal. to the energy requirement of the organism. As the protein, it is found that 10.8 mg. are used up, which, at 4.25 cal. per mg., represents 45.8 cal. contributed by protein. The factors 9.45 and 4.25, which convert fat and protein to calories apply to adult tissues. When applied to yolk conversion, they must be regarded only as approximations.

The above relationships, with deduced gas exchanges, are brought together in the following list, from which it is to be seen that up to the end of the yolk sac period the cost of constructing a salmon embryo is 114 cal., the larger portion coming from fat (carbohydrate may be neglected.) The living embryo, when the yolk is quite gone, weighs about 120 mg. so that each mg. of living material costs just under 1 cal. The weight of a dried embryo being some 17 mg., nearly 7 cal. are expended per mg.

	PROTEIN	FAT
Mg. burnt up	10.8	7.2
Calories liberated	45.9	68.0
Ml. oxygen consumed	10.3	14.3
Ml. CO_2 produced	8.2	10.2

In a general way, the above results from Hollett and Hayes (1946) are like those previously reported, although close agreement is not to be expected because, as already mentioned, it is not easy to say exactly at what point to consider the yolk phase at an end. To minimize the difficulty, the protein and fat used may be set down as a percentage of the total material taken for energy purposes. The comparison then becomes:

	PROTEIN	FAT	REFERENCE
Salvelinus fontinalis	63	37	Gortner (1913)
Salmo irideus	84	16	Smith (1942)
Salmo salar	60	40	Hollett & Hayes (1946)
			Hayes & Ross (1937)

The efficiency of development may be obtained by comparing calorific expenditure with stored embryonic energy. The latter is obtained from our analyses as follows, each value representing the composition of one embryo from a 130 mg. egg at the time the yolk is completely used up.

	MG.	CALORIES	REFERENCE
Ash	1.2	—	Hayes, Darcy, & Sullivan (1946)
Protein	12.6	53.7	Hollett & Hayes (1946)
Non-protein nitrogen compounds	0.7	3.0	Hollett & Hayes (1946)
Fat	2.2	20.8	Hayes & Ross (1936)
Carbohydrate	0.6	2.5	Hayes & Hollett (1940)
Total	17.3	80.0	

The energetic result of development is thus 80 calories. It was seen above that the combustion represents 114 calories. The efficiency is therefore

$$\frac{80 \times 100}{114 + 80} = 41 \text{ per cent}$$

which represents energy incorporated in the living embryo, the remaining 59 per cent going for osmotic work, secretion, circulation, etc., as well as for swimming in later stages.

The citations from the work of Smith (1942) are taken from Needham (1942), who had seen the former's Cambridge Inaugural Dissertation in manuscript. The first part has recently been published (Smith, 1947), and when the rest is available it will be interesting to attempt a detailed comparison of his results with our own. He has made direct measurements of heat production as well as chemical analyses.

Another way to calculate efficiency is by a comparison of the weight changes in embryo and yolk during development. This has been done by Hayes and Pelluet (1945) in relation to temperature, the results being given below. At cool temperatures the efficiency turned out to be about the same as given above; in warmer water it was higher.

Attempts have sometimes been made to divide the embryonic requirements into energy for (a) differentiation, (b) growth, (c) maintenance, and (d) extraneous activities such as swimming. All these possibilities and others were discussed by Needham (1931, pp. 946–999), from whose discussion it is evident that quantitative data are so far behind theory that little progress has been made. The above value of 41 per cent, which is simply the ratio of output to input as used in industry, is known to embryologists as the apparent energetic efficiency. The efficiency of contracting mammalian muscle is generally given in texts as about 25 per cent, while the efficiency of development of a frog embryo is 51 per cent, and of a *Fundulus* embryo, 53 per cent (Needham, 1931, p. 968). Thus the value for the salmon, while higher than that for adult tissues, is below those previously reported for embryos.

VI. Sequence of Energy Sources

It has been suggested by Needham as a provisional generalization of chemical embryology that "during development, there is a succession of sources of energy, carbohydrate preceding protein, and protein preceding fat" (1931, p. 1656). The statement is somewhat modified in his later book (1942, p. 603), in the light of respiratory measurements made on amphibians and sea urchins. As to the salmon, we can see no clear evidence in support of the proposition. Carbohydrate, being continually on the increase, can hardly be a donor of energy. Reasons already given suggest that fat is the likely pre-hatching source of energy, while halfway through the post-hatching period a maximum of fat combustion is again reached (Fig. 11). Before and after the latter, the dominant source must be protein. Thus the dominant sources of salmon energy occur in the following sequence: (1) fat, (2) protein, (3) fat, (4) protein.

It might be noted that R. Q.'s in the first stages of development are not very reliable because (a) the gas exchanges approach the limits of the methods, and (b) there are likely to be initial alterations of pH involving carbon dioxide. Thus the first measurement of the R. Q. in *Fundulus* was 0.9 (Amberson and Armstrong, 1933) while that of the trout was 2.4 (Schlenk, 1933). If we take the interval from fertilization to hatching in a fish as corresponding morphologically to the first five days of chick development (Hayes and Ross, 1936), then the high R. Q.'s just mentioned would be ended, and the fat level established, in less than a single chick day. In the chick itself the period of carbohydrate combustion actually occupies seven days (Needham, 1931, p. 993; 1942, p. 592). There is evidently a fundamental difference in the utilization of energy sources between the teleost and chick egg.

VII. Mineral Metabolism

A. Coelomic Eggs and Coelomic Fluid

In the Salmonidae the ripe eggs lie freely in the coelom. Just before they are laid a quantity of coelomic fluid, clear, limpid, and slightly translucent, appears in the body cavity of the parent fish (Greene, 1904). In Fig. 12, the composition of the coelomic fluid is compared with that of the eggs in it (the latter called "early yolk"). It appears that *in the coelomic fluid* (1) sodium is the dominant base, and chloride the dominant acid; (2) base is in excess of acid, which indicates that protein is used for binding base; (3) the relative distribution of ions is in accord with analyses of sea water and vertebrate serum (Macallum, 1926). *In the coelomic eggs*, (4) potassium is the dominant base, but large proportions of calcium, magnesium, and sodium are found as well; (5) there is a large excess of base over acid, to be accounted for by assuming that some of the protein is used for base-binding, and that most of the Ca and Mg is not ionically active.

Several workers have recorded measurements of freezing-point depressions, Δ, in spawning salmonids, and from these measurements the line marked "cryoscope" has been placed on Fig. 12. It is reported that ripe eggs in the coelom are

somewhat hypotonic to blood, whereas the coelomic fluid is markedly hypotonic to blood, and that the total base in the coelomic fluid accounts correctly for the osmotic pressure reported in the published studies. However, as Fig. 12 shows, the total base of the early yolk, if

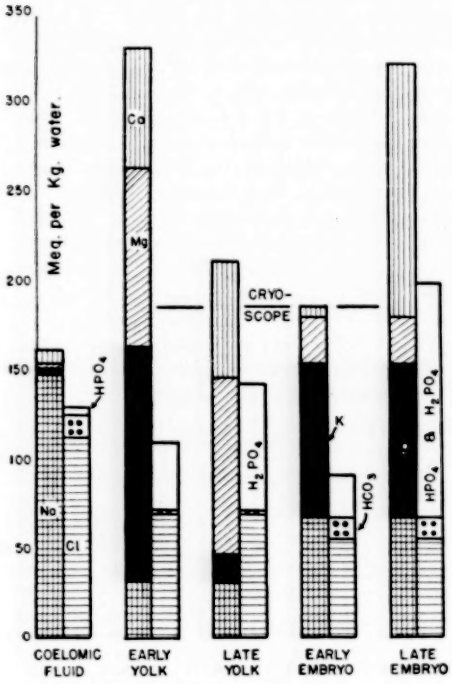

FIG. 12. A COMPARISON OF THE IONIC CONSTITUTION OF THE COELOMIC FLUID WITH THE EGG IN THE COELOM (EARLY YOLK) AND WITH LATER STAGES

Cryoscope line based on data from Atkins (1911), Bogucki (1930), Runnström (1920), Schmidt-Nielsen and Schmidt-Nielsen (1925), and Greene (1904). Yolk becarbonate from Irving and Manery (1934). Other values from Hayes, Darcy, and Sullivan (1946). Bialaszewicz (1927) has also estimated minerals in salmon eggs. His results, except for Ca, are somewhat lower than those shown, but are in substantial agreement, especially in ratio to one another.

assumed to be osmotically active, would give results that are one-third higher than reported cryoscopic measurements. But the calculated Δ due to the Na and K is only slightly lower than that observed. Analytical results and direct measurements may be brought into agreement if it be assumed that all or nearly all of the Na and K is active, while only a small proportion, 10 to 15 per cent, of the Ca and Mg participates in osmotic phenomena, the remainder being organically bound.

Bialaszewicz (1929) developed an ingenious technique to separate the "dispersed phase" or colloidal phase with its non-participating inorganic constituents from the "intermicellar liquid." In *Salmo fontinalis* yolk he found that the following percentages of the substances named were organically bound, and hence inactive: K, 11; Na, 49; Ca, 73; Mg, 68; Cl, 0; total P, 90. His method is theoretically sound and the general conclusions warranted. The results, however, present quantitative difficulties which have been discussed by Krogh (1939, p. 171). In the yolk of the hen's egg Δ calculated from analyses is 1.22, whereas the observed value is only 0.60 (Straub and Donck, 1934). The authors believe that the predominant base, calcium, is largely bound to lecithin.

The follicular fluid of the cow or pig is hypotonic to blood and presumably to eggs (Howard, 1933). In the chick egg the white is reported to be hypotonic to the yolk (Straub, 1929). How are such differences maintained? Straub proposed that work was done and energy expended at the yolk-white boundary to maintain a secretion of ions across the membrane. There are difficulties with the application of such a theory to the chick (Needham, 1942, p. 11), and in the salmon there is no likelihood that the oxygen necessary to liberate energy could diffuse to the egg mass in the coelom. As to the possibility of energy through glycolysis, there is hardly sufficient carbohydrate to carry out the necessary osmotic work (see above). The only remaining suggestion is that of Howard (1944), who believes that the frequently observed high Δ in chick yolk is an artifact due to the peculiar physical properties of yolk and that the apparent osmotic difference between the yolk and white does not exist at all.

B. Changes During Development

It has been suggested that most of the Ca and Mg in the early yolk is osmotically inactive. The large stores of these substances remain unchanged in concentration during development (Fig. 12, "late yolk"), but K diminishes so greatly that the others must be drawn into the osmotic picture to restore the balance. Potassium appears to be the only ion in which a specific selective power by the embryo from the yolk can be demonstrated, i.e.,

K^+ is the only ion whose concentration changes strikingly in the yolk during development. The egg appears to be provided with barely enough K to carry the embryo through to feeding time, but in spite of this there is some loss to the outside (Fig. 13), so that the larval system is not wholly efficient in conserving its stores. It is interesting that the developing larva, despite the shortage of K, appears unable to absorb any from the water. The embryonic concentration of K remains fixed at some 86 meq. per kilo of water (Fig. 12). In the rainbow trout, according to Leulier and Paulant (1935), K remains constant at 95–100 meq. until the young fish have reached a weight of 10 g. It thus appears that the K level of the earliest stages is maintained permanently.

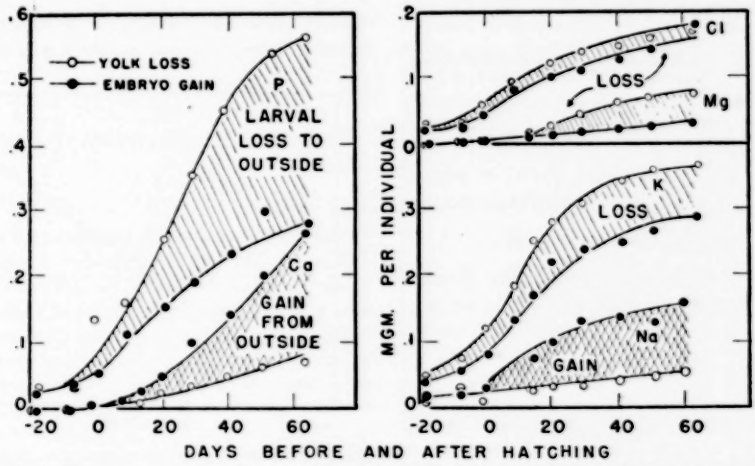

FIG. 13. A COMPARISON OF THE LOSS OF EACH MINERAL FROM THE SALMON YOLK WITH THE GAIN BY THE EMBRYO

When the embryo curve is above the yolk curve, an uptake from the surrounding water is indicated. This is so in the case of sodium and calcium; other substances sustain a loss during development. From Hayes, Darcy, and Sullivan (1946).

During development there is a clear uptake of Na and Ca from the water, while the system suffers depletion of other ions. McCay et al. (1936) have reported an increase of calcium during the development of brook trout. Manery and Irving (1935) have reported a decline in trout chloride during the egg phase. Fig. 13 confirms both these results.

TEMPERATURE EFFECTS

The accelerating influence of rise of temperature on growth has always been known to biologists, but it is less than a century since the first quantitative observations on eggs were made. Davy in 1856 and Coste in 1858 gave some fragmentary figures showing that warmed water speeds up the development of salmon eggs. Probably the first modern work was done in 1859 by Stephen H. Ainsworth, who experimented with eggs of the brook trout, *Salvelinus fontinalis*, in a little spring-fed pond near West Bloomfield, New York. His table showing the incubation periods of eggs at various temperatures was published by Norris in 1868. It has since been so widely used in hatcheries and elsewhere, that its authorship is generally forgotten. Ainsworth's values are placed on Fig. 14 side by side with the best data now available for the brook trout (Embody, 1934), and it is clear that his observations were remarkably accurate, particularly in view of his statement to Norris that he estimated a little in the higher and lower figures, since the water did not hold at the temperatures indicated long enough to hatch the ova.

1. Temperature Equations

Theories have been advanced from time to time on the best way to deal mathematically with temperature effects. The oldest still quoted is that of Seth Green (1870), who stated that "trout eggs will hatch in 50 days at a mean water temperature

of 50°F. and for each degree colder or warmer five days more or less will be required, the difference, however, increasing the farther we recede from 50 degrees." Since Green's time more precise formulations have been made, a few of which will be discussed here.

A good formula is one of maximum simplicity, which permits the data to be represented on a graph as a straight line, shows readily the places of deviation from the straight line plot, does not imply any underlying theory which the facts cannot sustain, and fits the general class under consideration, e.g., fish embryos. No formula has been

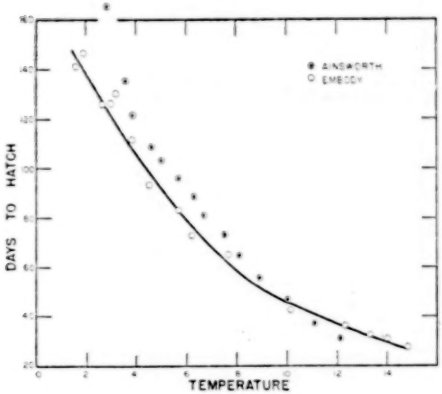

FIG. 14. EFFECT OF TEMPERATURE ON THE TIME FROM FERTILIZATION TO HATCHING IN THE BROOK TROUT SALVELINUS FONTINALIS

From Ainsworth (published by Norris 1868) and Embody (1934). Curve drawn through Embody's values.

or is likely to be found which is applicable to all or indeed most biological material, a misfortune which led Needham to remark that the "acceleration of embryonic development with rise of temperature is in itself a banal phenomenon, and its mathematical analysis leaves us only with further enigmas" (1942, p. 336). It may be noted at the start that temperature effects on biological material are sometimes plotted as time (days to reach a certain stage) and sometimes as rate (number of heart beats per minte), the rate being the reciprocal of the time or some multiple thereof. Time curves and rate curves do not look alike, as will be seen by comparing Figs. 14 and 15.

In the discussion to follow these symbols will be used:

y = time to reach a certain stage (days from fertilization to hatching in the example chosen).

v = rate, or velocity, 1000 times the reciprocal of y.

T = Temperature in degrees centigrade.

k_0 and k_1 = respectively intercept and slope constants, whose values vary with each of the theories under consideration.

A. The Velocity Curve

Krogh (1914) observed that in various embryos, including those of several marine fishes, the rate

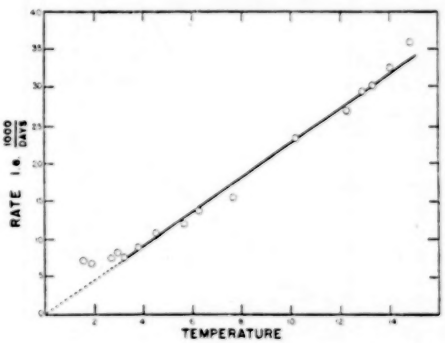

FIG. 15. EMBODY'S TROUT DATA FROM FIG. 14 PLOTTED AS RATE INSTEAD OF TIME

Rate is taken as 1000/days to hatch. The curve becomes a straight line with deviations at the bottom and perhaps at the top.

of development when plotted against temperature gives a straight line, that is, the relationship conforms to the intercept formula

$$v = k_0 + k_1 T$$

Application of a Krogh plot to Embody's trout data is shown in Fig. 15. Over most of the range the fit to a straight line is good, but at the lowest temperatures (below 3.5°C.) the values tend to deviate above the expected, while the highest point or two may also be off the line. Krogh noticed that this occurred in a variety of material, and he thought that the portion of the curve over which the linear relation holds might have some meaning. At the warm end of the range, development would tend to be interfered with, resulting

in the production of an increasing number of abnormal embryos and a high death rate. It is indeed obvious that excessive heat will injure animals. The meaning of the deviation at the cold end, however, was not clear to Krogh (and still remains not clear).

Thermal Summation and Thermal Units. Other ways of expressing the relationship just discussed were published before Krogh's paper. These will be clear if we consider what Krogh has said, implicitly, about the original time-temperature curve, (Fig. 14). Looking first at the extrapolation of the velocity curve (Fig. 15), it will be noticed that zero rate theoretically will occur at zero degrees, so that

$$k_0 = 0$$

from which it follows that

$$yT = K$$

i.e., the time necessary to reach a definite stage of development multiplied by temperature is a constant. Thus Fig. 14 is defined as a rectangular hyperbola. The last equation given is said to have originated with Réaumur (1735), was first applied to botany by Boussingault (1851) as the rule of thermal summation, and has since found wide application in biology.

Wallich published in 1901 an account of time-temperature relations for the Pacific salmon, *Oncorhynchus tschawytscha*. He desired to give hatchery men a guide to the time at which eggs under various thermal conditions reach the critical stage, earliest shipping age, latest shipping age, etc. To do this, he drew up the "time-temperature or thermal unit system," defining a thermal unit as a temperature of 1°F. above 32°F. for 24 hours. Thus 36°F. for one day equals 4 thermal units, etc. The number of thermal units required to hatch an egg proved to be about 900 at all the temperatures investigated. A little consideration will show that Wallich is simply stating that

$$yT = K$$

His temperature ranges averaged from 5°C. to 10°C., a range for which the data plotted in Fig. 15 confirm his views by exhibiting a straight line relationship. Had his work involved many days of temperature below 3°C., the results would not have conformed to the theory, since, as the early points on Fig. 15 show, a further decline in temperature is accompanied by a drop in the number of thermal units required to hatch an egg. Indeed, Wallich himself said: "In many stations, it is true, hatching operations are conducted in waters that are very cold, and it would seem that the eggs of Salmonidae could hardly be subjected to as many as 900 t.u. before hatching."

Reibisch (1902), being acquainted with the work of Boussingault, and working with marine fish eggs, concluded that

$$yT = K$$

provided that temperature is reckoned from the lowest point at which development can take place at all, a point which for his material was the freezing point of seawater. (On a Krogh plot this point would be the temperature at which the extrapolated curve showed a zero rate. In the trout this happens to be zero temperature). Call the threshold temperature x and

$$(T_1 - x)y_1 = (T_2 - x)y_2$$

where T_1 and T_2 are temperatures at which incubation requires respectively y_1 and y_2 days.

From the foregoing discussion it is clear that the equation

$$yT = K$$

and the corresponding

$$v = k_0 + k_1T$$

have been repeatedly proposed in one form or another. They have been applied to developing eggs of various kinds, as well as to other plant and animal phenomena. The mathematical relationship is simple and is not associated with any overthrown theory. Of the two equations, the one dealing with rate is to be preferred because it yields a straight line, requires no temperature adjustment, and clearly shows the place at which deviations from the line occur. In many phenomena, e.g., heart beat, the rate represents the original form of the observations. There is no equation that will describe all temperature results, but this one is as generally applicable as any other and is also simpler than any other.

B. Temperature Curve as a Parabola

Bělehrádek (1930), believing that Krogh's formula, though good, could be improved upon, subjected temperature data to a logarithmic plot

and found a straight line relationship in many cases, i.e.,

$$\log v = \log k_0 + k_1 \log T$$

This is the formula for a parabola, so that Bělehrádek regards time and rate curves (Figs. 14 and 15) as parabolas. Porodko, he stated, had independently proposed the same equation at about the same time, from a study of plant material. Now the parabola (as has been pointed out by Ludwig, 1929) is an extraordinarily pliable curve, since concave, convex, or straight lines can be a part of it, and consequently almost any curve can be built up out of parts of parabolas. If a time correction be added whenever necessary (as Bělehrádek proposed), then almost any data can be fitted by this formula.

The slope of the Bělehrádek curve has been found in general to lie between 0.6 and 4.0, and very often it lies close to 1.0. When the slope is 1.0 ($k_1 = 1$), the equation becomes identical in form with Krogh's formula. Thus Krogh's relation and the rule of thermal summation of Boussingault form a special case of the more general Bělehrádek formula. What the latter has attemped is to take in a much wider variety of data than Krogh. The consequence is a loss of precision, an increase in complexity, and a diminution in usefulness to the biologist.

C. Van't Hoff's Law

The temperature formula most familiar to biologists is associated with the coefficient Q_{10} and is known in English as van't Hoff's law, and in German as the RGT Regel (Reaktionsgeschwindigkeit-Temperatur-Regel). The history of the formula has been given by Bělehrádek. Van't Hoff's law is said to apply whenever a plot of the logarithm of the rate (or time) versus the temperature gives a straight line.

Results are expressed as values of Q_{10}, which is the increase in rate (or decrease in time) that accompanies a rise in temperature of 10°C. Q_{10} values, being quotients, are inherently of low accuracy, and when plotted from the original points without preliminary smoothing of the curve, exhibit violent fluctuations. The remarks on errors in growth rate curves in an earlier section apply equally well to Q_{10} calculations.

D. Interpretation of the Q_{10} Coefficient

Biologists today use the Q_{10} coefficient without any reference to the chemical theories on which it was originally founded. Taking this lead, the three formulae which have been considered already may be compared directly by expressing each of them in terms of the Q_{10}, as in Fig. 16.

Krogh (top row), finding that the plot of rate vs. temperature gives a straight line, concluded that the Q_{10} drops from infinity to one. In the temperature range of life, the drop is from 6 or 8 to 2 or 3.

Bělehrádek (middle row), undertook to get rate versus temperature plots into a straight line whether they are straight in the first place, as

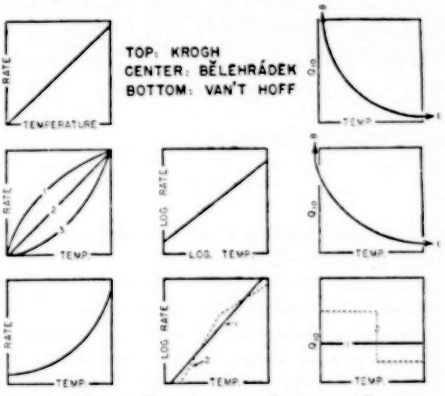

FIG. 16. THREE TEMPERATURE FORMULAE BROUGHT INTO COMPARISON BY ASKING WHAT EACH PURPORTS TO TELL ABOUT Q_{10}

Krogh and Bělehrádek both say that as the temperature is increased the Q_{10} drops, rapidly at first, and then more slowly. Van't Hoff says that as long as log rate versus temperature is a straight line, the Q_{10} is constant. When difficulties arise the line is broken, which would make the Q_{10} undergo a sudden drop. The net result is then very much like the others.

Krogh found (curve 2) or whether they bend above or below a straight line (curves 1 and 3). This was done by plotting log rate against log temperature (or log corrected temperature). The conclusion about the Q_{10} was the same as Krogh's, namely, that it drops smoothly from infinity to one. In general, if a Krogh plot suits there is no occasion to complicate matters by making a Bělehrádek plot.

Van't Hoff (bottom row), considered that the plot of rate versus temperature was an exponential curve, and hence that the plot of log rate versus temperature was a straight line. This should hold over a wide range of temperature (curve 1 of center figure), which would make

Q_{10} a constant. It soon turned out, however, that in many or even in most cases, the log rate versus temperature data require two or more straight lines for a fit (curve 2). The temperatures at which these lines intersect are called "critical temperatures," since at them there is a sudden drop in the Q_{10}. It will be seen that the net result of Q_{10} curve 2 is the same as the other authors' Q_{10} curves, but that van't Hoff walks down the stairs while the others slide down the bannister.

Arrhenius proposed an improvement on van't Hoff's formula, the theoretical grounds of which need not be considered here, since they are now universally admitted to be inapplicable to living systems. The Arrhenius equation is said to apply when a plot of log rate against the reciprocal of the absolute temperature gives a straight line. The only thing that need be said about this formula is that for all practical purposes in biology it is the same as "van't Hoff's law." Any Q_{10} value for salmon and trout can be converted to the corresponding value of Arrhenius' formula with negligible error (5 per cent) if multiplied by 5500.

II. Individual Effects of Temperature

A. Growth and Maintenance

Hayes and Pelluet (1945) made a study of the effect of temperature on the growth and efficiency of yolk conversion in the salmon. In this instance it was found that a Krogh plot gave a straight line only in the interval above 10° for embryo growth, and above 6 for yolk depletion; thus it was hardly applicable. The Bělehrádek curve could be used only when rather extensive corrections were applied, which appeared to detract from its utility. As to the van't Hoff curve, it could be used with a break in the middle, as in Fig. 16, bottom center. On the whole, no formula was strikingly superior to the others. The effect of temperature on the efficiency of development was also worked out, efficiency being defined by the ratio

$$\frac{\text{embryo gain} \times 100}{\text{yolk loss}}$$

Under cooler conditions efficiency was at a minimum of less than 42 per cent, which means that more than half of the yolk was used up in the process of converting the rest into embryonic tissues. The efficiency remained constant at this low value up to approximately 5°, after which it began to rise and continued rising until at the warmest temperatures a maximum of nearly 60 per cent efficiency was reached.

It would be instructive to know whether a difference exists between the Q_{10} for growth and the Q_{10} for maintenance. One might expect such a difference, since there is, at higher temperatures, an obvious increase in activity, such as swimming movements, which does not necessarily correspond to an increase in growth. Values may be obtained for the yolk used up for maintenance by subtracting the embryo gain from the total yolk loss. From the resulting series a Q_{10} curve for maintenance was plotted by Hayes and Pelluet, and this curve turned out to be indistinguishable from the corresponding growth curve, so that one is led to the conclusion that the two processes are affected in the same manner by temperature changes.

B. Dissociability of Embryonic Processes

The experiments just described dealt with growth and maintenance. It is of interest to discover whether differentiation is affected in a similar way, but good methods for the measurement of differentiation have been difficult to devise. Minot (1891) proposed to take the proportion of actively dividing cells as a criterion, and his ideas have been developed by Richards et al. (1935). The method, however, is both laborious, since sections must be made at all stages, and really applicable only to quite young embryos. Ljubitzky and Svetlov (1934) reported a difference between temperature effects on the growth and the differentiation of trout eggs. In the development of the pectoral fin, they found that: (a) the initial formation of the bud and the appearance of the skeletal and muscle anlagen were accelerated by temperature to about the same degree as development as a whole; (b) histological differentiation, including cartilage and myofibril formation, was accelerated by temperature to double the general rate; and (c) later differentiation and the assumption of definitive form by the fin were not affected by temperature at all. Ljubitzky (1935) has published similar results on earlier trout stages, from which observations it appears that the rate of development from fertilization to the first appearance of the embryonic shield (multiplication of undifferentiated cells) is doubled or trebled by a temperature increase of 10°C. By contrast, the rate during the period of organogenesis, from the embryonic shield stage to the 27 somite stage (blastopore

almost closed) is increased 8- to 10-fold by a 10° rise. Further work will be necessary before such interesting results are clearly established, first because the judgment of embryonic stages is neither easy nor accurate, second, because of that inherent inaccuracy of thermal coefficients mentioned above, and third, because these pectoral fin studies ended at a stage just before hatching, a time when a general inhibition of development at high temperatures is common, especially in still water (see below).

Hayes and Pelluet (1945) attempted to measure the effect of temperature on salmon differentiation, using a special series of stages drawn up by Pelluet (1944). When the experiment was started the salmon were in Stage 13, which in this instance coincided approximately with hatching. (Hatching itself is not regarded as a stage, since, as already mentioned, it can occur quite variably). Stage 13 is characterized by the appearance of fin rays in the tail, with an accompanying loop of blood vessels. The plan of the experiment was to measure the time of development from this stage to Stage 14 at each temperature, and thus to obtain a measurement of the rate of differentiation. The plan was unsuccessful for a very interesting reason. The very problem under investigation, namely the uncoupling of embryonic processes, intervened as a disturbing factor. Stage 14 had been drawn up on the basis of observations on embryos developing in water of an intermediate temperature, perhaps 6° on the average. In this thermal environment several morphological events happen together, which were described and illustrated by Pelluet, and these events, in the aggregate, were taken to define Stage 14. For instance, the fat cells in the mesentery can be first noticed at the same time that the gut has become turned through a right angle. But in the coldest of the experimental chambers, the gut never turns through a right angle even though the fat has multiplied in the mesentery to a point equivalent to that of Stage 15, as originally described. On the other hand, in the warmer chambers the gut turns through a right angle and development proceeds until the conspicuous pigment patches illustrated in Fig. 15a (Pelluet, 1944) have appeared, but during all this time no fat ever appears in the mesentery. Evidently, therefore, temperature is capable of altering the order of morphological events, and hence in these experiments Stage 14 could not be designated with confidence.

These experiments were extended by Hayes and Gorham (1949, in press), who noted the time required for some fifty diagnostic morphological features to appear as the eggs developed at different constant temperatures. Such criteria were included, for instance, as the pigmentation of bile, establishment of the circulation, etc. The manner in which processes are dissociated by temperature is shown in Fig. 17. It is to be seen that the bile curve crosses the curve for the establishment of tail circulation at 5.5° and crosses the yolk circulation curve at 11°C. Thus at cold temperatures the embryo tends to develop its blood circulation precociously (relative to the development of the digestive system), whereas at the warm end of the range the function of the liver tends to appear before blood vessels are available to supply it fully. It may well be that at extremes of temperature certain tissues will exhibit cell multiplication without any differentiation at all, while others cease to multiply. In some of the embryos it was observed, for example, that at low temperatures the whole gut tract failed to form, while in others there were no jaws.

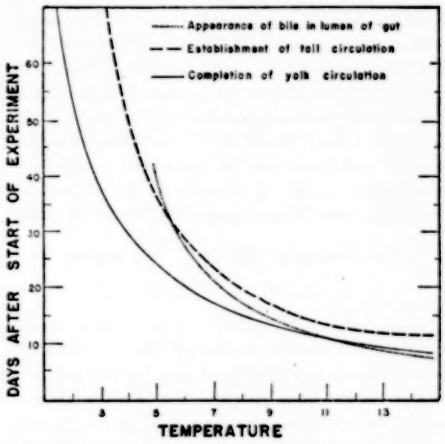

FIG. 17. THE TIME REQUIRED FOR THREE MORPHOLOGICAL FEATURES TO DEVELOP IN THE SALMON EMBRYO AT DIFFERENT TEMPERATURES
From Hayes and Gorham (1949, in press).

In a general way, one might consider growth and differentiation as taking place in a mutual relation

of limited flexibility, rather like two essential services of an advancing army, either one of which might get a little ahead or a little behind from time to time, but cannot stray too far from the other without disrupting the whole organization (Needham, 1933). It is probable that there is an optimum temperature of development at which the two processes stand in an optimum relation to one another; this should be the temperature at which there is a minimum death rate of embryos. Deviating from the optimum temperature, one would finally reach an extreme at which the two processes are so far out of coordination that survival of the embryo is no longer possible. As the question now stands, it appears that the relationship of growth to differentiation is a matter considerably more complex than had been supposed, and the classical idea of an embryonic "stage" will have to be abandoned.

THE EFFECT OF AGE ON MORTALITY

It is a hatchery man's rule of thumb that eggs can be handled quite roughly for about 36 hours after fertilization, but that after that time they must be disturbed as little as possible until the "eyed stage" is reached, i.e., almost half-way to hatching. There is clearly a period of great susceptibility in the early part of the egg stage. By way of establishing the point of maximum delicacy, Steuert (1906) measured the resistance of trout eggs to "mechanische Insulte." He found the time of maximum susceptibility to be in the period 10 to 17 days after fertilization (the eggs took 50 days to hatch). In the following year Hein published the results of similar and more extensive experiments, also conducted on trout. These experiments showed 15 days after fertilization to be the most critical time for the eggs (54 days to hatch).

Hayes and Armstrong (1942) confirmed the applicability of these results to the salmon and noted that the period of maximum death rate corresponds to the closure of the blastopore, i.e., to a time when the vitelline membrane over the yolk is replaced by a layer of cells. Hence the immediate cause of death in early stages may be rupture of the vitelline membrane. It has often been noticed that in dead eggs the membranes seem to have slipped up and formed a crumpled mass at the top. It is natural to think that the closure of the blastopore would make this less likely to happen. Still later in egg development, the yolk sac becomes very heavily protected by a composite layer of ectoderm, somatic mesoderm, coelom, splanchnic mesoderm, and endoderm. By this time the eggs will stand very rough handling.

In the cod egg it appears that the period of maximum susceptibility is rather earlier and has already passed by the time the blastopore has closed (Rollefsen, 1932; Bonnet, 1939).

In the early mortality period just described, the sign of death is a general whitening of the egg. Another period of major loss occurs shortly before hatching, and here it is the embryo and not the yolk which first becomes opaque (Hayes, 1930). Pre-hatching death is greatly accelerated by an increased temperature and can be abolished by artificial hatching. Death, of course, represents the extreme point at which adverse conditions may be measured. Sublethal effects of various kinds have also been observed. Thus Hayes and Armstrong (1943) noted an interruption of the growth rate curve of the embryo at hatching time. Also Hayes and Ross (1936) observed a drop in the fat content of the embryo while hatching was in progress. Moreover, Saunderson (1935) plotted the area of the cartilage in the head against time and found that, following a rapid pre-hatching development, there was an abrupt cessation of cartilage growth until three weeks after the larvae had hatched, when its rapid growth was again resumed. Finally, the synthesis of carbohydrate by the developing larva is interrupted over the hatching interval (Hayes and Hollett, 1940). It is therefore clear that at hatching there occurs a general pause in the building of new structures and the synthesis of new materials.

The pre-hatching death, particularly at higher temperatures, may be due to an insufficient diffusion of oxygen through the capsule to meet the needs of the already well-grown embryo. The Q_{10} for the diffusion of oxygen is only 1.3 (Bělehrádek, 1930), while the Q_{10} for the embryonic demand is 2 to 8 (see above). If the egg were using all the oxygen it could get by diffusion at lower temperatures, there would not be enough to keep it alive at higher temperatures. The idea of oxygen lack as a cause of death is made plausible by some recent work of Moore (1940), who has stated: "Those species of frogs (e.g. *Rana sylvatica*) breeding early in the spring when the water is cold have a submerged compact jelly

mass. The closely crowded eggs, however, die of asphyxiation at temperatures such as those existing in the environment in which the [summer breeding forms] *Rana clamitans* and *Rana catesbeiana* breed. The latter two species deposit their eggs in a surface film that insures a better supply of oxygen." It is of interest that the death of the eggs of *R. sylvatica* at 25°C. can be prevented by substituting oxygen for air. The available evidence for salmon is shown graphically in Fig. 18, in which the oxygen consumption at various tensions of eggs ready to hatch is compared with that of artificially hatched larvae of the same batch. Given abundant oxygen, the hatched larvae, being free swimming, consume more oxygen than the eggs (horizontal line). As the oxygen tension drops, the eggs begin to show a decline in consumption at about 95 mm. Hg. For hatched larvae the point corresponding to that at which the maximum oxygen delivery to eggs takes place, is only 45 mm. Hg (where broken line cuts larval line). Similar results have been published by Lindroth (1942), who found that the sensitivity to lowered oxygen tension varies with the stage of development of salmon eggs. At 10°, for example, the critical tension (where curves of the type of Fig. 18 would break) were as follows: for newly fertilized eggs, less than 10 mm. Hg; for newly hatched eggs, 30 mm. Hg. The effect of temperature on the limiting tension in advanced eggs is apparent from Fig. 19, which shows that at 17°C. the curve has not flattened even at the maximum tension tried, which was approaching full atmospheric conditions. Clearly, a larva within the capsule must be in a less favourable position than a hatched larva, for the oxygen has to diffuse through the capsule, and also because the surface of a sphere is minimal. Furthermore, since the hatched larva is capable of some movement, it is less likely to develop a low oxygen pocket in its immediate surroundings, such as would tend to occur in water without much circulation.

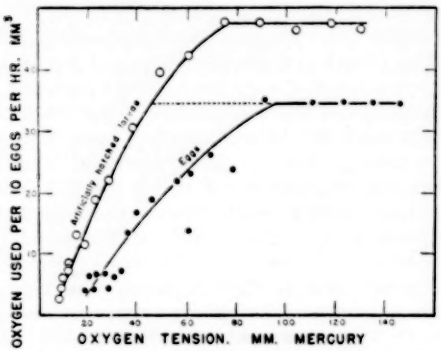

FIG. 18. POLAROGRAPH MEASUREMENTS OF THE EFFECT OF OXYGEN TENSION ON OXYGEN CONSUMPTION IN SALMON EGGS AND IN ARTIFICIALLY HATCHED LARVAE OF THE SAME AGE AND BATCH

Observations made at 10°C., shortly before normal hatching time. The egg line breaks at 95 mm. Hg, while the corresponding point for the hatched larva is 45 mm. Hg (where broken line cuts larval line). Evidently low tensions are more serious before than after hatching. From Hayes and Wilmot (1949, in press).

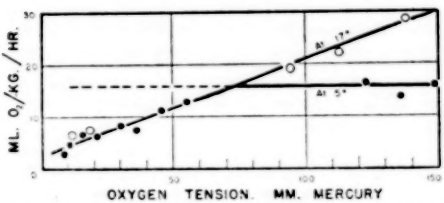

FIG. 19. EFFECT OF OXYGEN TENSION ON OXYGEN CONSUMPTION IN SALMON EGGS NEARLY READY TO HATCH

At 5°C. the limiting tension is about 70 mm. Hg. At 17°C. it is greater, being at least 140 mm. Hg. From Lindroth (1942).

Fig. 19. Effect of Oxygen Tension on Oxygen Consumption in Salmon Eggs Nearly Ready to Hatch

At 5°C. the limiting tension is about 70 mm. Hg. At 17°C. it is greater, being at least 140 mm. Hg. From Lindroth (1942).

SUMMARY

1. There is a rapid uptake of water by an egg when laid, and this uptake is independent of fertilization. The water does not enter the yolk but forms perivitelline fluid under the capsule. The swelling is inhibited by dilute sea water. Little if any salt loss from the egg occurs. The capsule becomes tough and insoluble within a few hours.

2. About halfway to hatching, the egg capsule begins to soften, the mechanism of the change being unknown. The capsule is not soluble in trypsin and but slightly in pepsin, but a few hours before hatching ectodermal glands in the embryo liberate an enzyme which dissolves the capsule. This hatching enzyme does not appear to act hydrolytically.

3. The growth of salmonid embryos is conveniently described by the formula of MacDowell et al.

$$w = k_0 (t - n)^{k_1}$$

where w is the weight, t the age, and n the time to establishment of the embryonic axis. Embryos

from small eggs are found to grow more rapidly than those from large eggs.

4. The egg starts out with little carbohydrate and sustains a continuous increase during development. No diminution of protein or fat has been directly observed before hatching, but indirect evidence points to fat as the most likely source of energy. By the time the yolk is gone, some 40 per cent of the original protein store is used up; the corresponding figure for fat is about 75 per cent. For the energy of development, about 3 calories are provided by fat to 2 by protein. In general, some 3 calories are burned up for every 2 stored by the embryo, i.e., the efficiency of development is about 40 per cent.

5. Cryoscopic measurements on yolk do not agree with mineral analyses unless one assumes that most of the Ca and Mg present is not osmotically active. During development Na and Ca are taken up from the water, other minerals being lost to the outside. The embryo specifically depletes the yolk of K during development.

6. The most widely applicable description of temperature effects, credited to Réaumur and repeatedly proposed since his time in one form or another, is

$$yT = K$$

where y is the time and T the temperature. Differences in temperature do not affect all differentiation processes alike, so that, e.g., bile formation is favoured by incubation at high temperatures, whereas yolk circulation appears relatively earlier in the cold.

7. Eggs are most likely to die either about the time of blastopore closure or shortly before hatching. The former critical period may be due to rupture of the vitelline membrane, the latter to failure of sufficient oxygen to reach the embryo through the egg capsule.

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A THEORY OF THE MECHANISM OF ENZYME ACTION

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INTRODUCTION

ALTHOUGH there exists an extensive literature concerned with the nature of enzyme action and the chemistry and structure of enzymes, little progress has been made toward understanding the mechanism of enzyme action in explicit terms of the molecular structure of proteins, prosthetic groups, and their combinations.

Woolf (1931), Szent-Gyorgyi (1941, 1947), and LuValle and Goddard (1948) are among those who have dealt with the problem and have proposed mechanisms, but while they have treated in detail certain of the fundamental aspects of enzyme action, they have given only cursory consideration to the structure and role of the protein components of enzymes. There can be little doubt that the protein portion of the enzyme molecule plays an essential role in its reactions. Indeed, many enzymes consist, so far as is known, entirely of protein.

Enough is known at the present time of the structure of enzymes, of the nature of enzymatic reactions, and of the kinds of substrates and products involved in enzymatic processes to justify the attempt to evolve a general hypothesis of the mechanism of these reactions. Except for the participation of inorganic ions, it is evident that enzymes are primarily organic compounds and that, in the majority of cases, they act upon organic substances, the reactions involving for the most part organic oxidations, reductions, hydrolyses, and condensations. In the present treatment the approach will be made from the following point of view: that reactions involving organic substances can be examined from the standpoint of present-day concepts of the nature and mechanisms of organic reactions.

It will be shown in this paper that it is possible to consider *all enzyme reactions to involve the same fundamental property of the protein molecule*, and that when prosthetic groups are essential participants in the process, as in oxidation-reduction reactions, the role of the prosthetic group is auxiliary and not an independent one. In short, it is suggested that enzyme reactions of all kinds have as a common denominator a unique and characteristic property of the protein molecule, which lies in its possession of a long hydrogen-bridged system of peptide linkages.

The question of the mechanism of enzyme action is essentially one of the means by which the enzyme brings about a sufficient lowering of the activation energy of a normally slow chemical reaction to cause its rate to be enormously increased over what it would be under non-enzymatic conditions and at comparable conditions of pH and temperature (see Kalckar, 1946).

ENZYMATIC OXIDATION-REDUCTION REACTIONS

The oxidation-reduction reactions which take place in living cells are mediated by a class of enzymes which have many characteristics in common. Their basic similarity lies in their ability to bring about the transfer of hydrogen to and from metabolites and interlinked enzyme systems which are undergoing oxidative changes in the organism. This transfer of hydrogen can be more explicitly regarded as a transfer of electrons, coupled with the addition or removal of protons by acid-base systems (such as water) in the medium.

The generalized scheme of the reaction sequence in which this transfer occurs may be represented as follows:

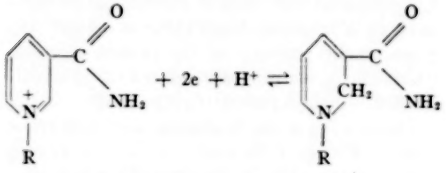
1. substrate_1 + protein-prosthetic group $\rightleftharpoons$ oxidized substrate_1 + protein-reduced prosthetic group
2. protein-reduced prosthetic group + substrate_2 $\rightleftharpoons$ reduced substrate_2 + protein-prosthetic group.

The substrates may be simple organic molecules, such as alcohols, sugars, acids, amines and amino acids, etc.; or other enzymes which act as links in

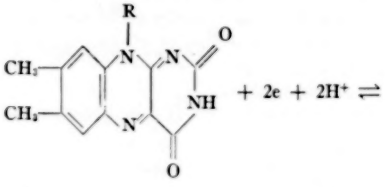
a chain of electron transport. In this way, hydrogen, or electrons, may be passed in a stepwise manner from an initial substrate (or metabolite) which is being oxidized, to another substrate which is undergoing an equivalent reduction.

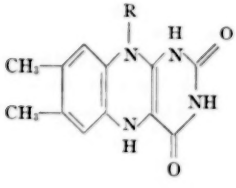
The prosthetic groups of oxidation-reduction enzymes fall into a relatively few classes, despite the large number of such enzymes known and the wide disparity in the kinds of substrates upon which they act. Indeed, it is possible to place these enzymes, on the basis of their prosthetic groups, into the following few groups:

1. The "pyridine" system

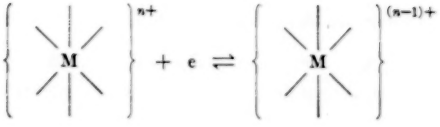


2. The flavin (isoalloxazine) system



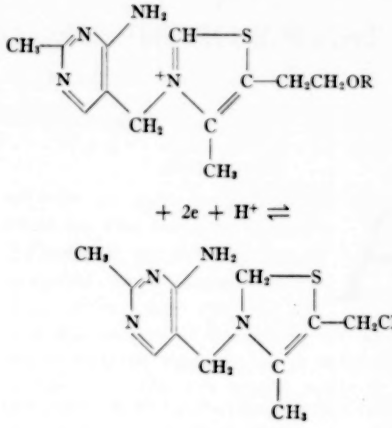


3. The metallo-porphyrin system



4. The thiamine system

While this system, which forms a part of the prosthetic group of numerous enzymes, has not been shown to participate in oxidative changes in a manner analogous to that established for the pyridine system, its close isosteric relationship to the latter has permitted the speculation (Lipmann, 1939) that in certain oxidation-reduction processes it may participate in the following way:



5. Metallic ions in other kinds of complexes

$$M^{n+} + e \rightleftharpoons M^{(n-1)+}$$

6. Other systems

Numerous systems are recognized which play an important and indispensable role in oxidation-reduction reactions, but whose precise mode of action is either unknown or speculative. Among these may be mentioned the system

$$—S—S— + 2e + 2H^+ \rightleftharpoons —SH + HS—$$

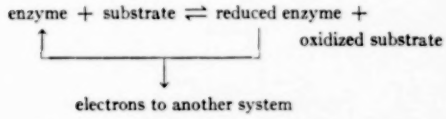
That this reaction occurs is known, but that it forms a link in any reversible stepwise process of electron transfer has not been demonstrated (Potter and duBois, 1943).

In the above structures, the residues "R" generally consist of complex groupings composed of one or more units of the following: ribose, adenine, or phosphoric acid. The exact nature of R can vary in such a way as to give rise to a group of closely related prosthetic groups; for example, coenzymes I and II and the isoalloxazine mono- and dinucleotides. The exact roles of the R groups in the performance of the enzymes in which they are found is not known. It is generally thought that they may serve as a means of attachment of the prosthetic group to the protein, but in any case it appears unlikely that they are concerned in the actual electron-transfer process per se.

The Enzyme as a Whole

A given enzyme consists of one of the above units in loose or rigid combination with a specific protein. It is generally considered that the specificity of the protein lies in the nature and arrangement of the amino acid residues which, joined together in polypeptide chains, constitute it. In no enzyme is any exact information available concerning the particular arrangement of the amino acid residues at that precise region of the enzyme (or protein) molecule at which the characteristic reaction occurs.

While the function of the prosthetic group has been indicated above, and will be considered in more detail in the sequel, the function of the protein is so far obscure. It is generally considered that the substrate (which may be a primary metabolite or another enzyme) combines with the protein to give rise to an enzyme-substrate complex in which the substrate is in some way "activated" so that it may release electrons to the prosthetic group and thence to a second substrate. In the overall process, electrons are transferred from one substance to another, the enzyme which catalyzes the change returning at the end of the process to its original oxidation level. The scheme may be represented as follows:



This oversimplified scheme is nothing more than a description of a gross process. In order to arrive at an understanding of the roles of all of the elements taking part in this transformation, it is necessary to examine in some detail the general properties of enzymes and the characteristics of oxidation-reduction reactions.

ELECTRON TRANSFER BY ENZYME SYSTEMS

One of the striking characteristics of enzyme-catalyzed reactions is the high "turnover number," i.e., the number of molecules of substrate oxidized per minute by a single enzyme molecule. It has been shown that, if certain conditions be assumed, diffusion rates alone can often account for the turnover numbers commonly found. One interpretation of this fact might be (1) that the "activated" substrate reduces the dissociable prosthetic group through the mediation of the specific enzyme; (2) that the reduced prosthetic group, after dissociation (desorption?) of the oxidized substrate molecule, passes on its hydrogen atoms to a receptor; and (3) that the reconstituted enzyme, after dissociation of the reduced, second receptor receives another substrate molecule and again passes through the same cycle. Whether this be interpreted as meaning that the protein-prosthetic group remains an entity, the various electron donors and receptors diffusing up to and away from it, or on the other hand that the prosthetic group is dissociable in its oxidized and reduced states, certain facts of enzyme chemistry are imperfectly accomodated in such a picture. For instance, some prosthetic groups, such as the iron atom in cytochrome C, or the reduced flavin system of some yellow enzymes, are not freely dissociable from their protein complements. Further, recent studies on native proteins (Wrinch, 1947) have led to the conclusion that in the living cell proteins exist in highly organized aggregates, and Green (1948) has discussed the enzyme-complex in terms of a "macromolecule" in which the various components of the hydrogen transport system bear an organized relationship to each other. It will be shown in the following discussion that this latter concept finds specific application in the hypothesis of the functional role of the protein in electron transfer.

An acceptable theory of enzyme action must take into account at least the following relations:

1. The high turnover number of enzyme systems;
2. The unique structure of the protein molecule, i.e., the repeated peptide linkage, and the roles of the side-chains;
3. The "activation" of the substrate;
4. The role of the prosthetic group, if one is involved;
5. The activation and inhibition of the enzyme by such substances as metal ions, drugs, oxidizing and reducing agents, etc.; and
6. The interrelationship of the members of a functionally related group, or series, of enzymes.

It has been established that the process of respiration in the cell involves a number of enzymes in a series, at one end of which the metabolite is oxidized (or dehydrogenated), and at the other end of which oxygen is reduced. Considering first the initial dehydrogenation of the substrate, the following questions arise:

1. By what detailed process do electrons leave the substrate and reach the atom or structural unit

of the prosthetic group? Is it the function of the specific protein to hold the substrate and the prosthetic group in such a spatial relationship to each other that electrons leaving the former can pass *directly* to the latter? In other words, is it the function of the protein to "bring together" the substrate and the prosthetic group?

2. What is the nature of the ensuing steps of the overall process? Does the reduced enzyme exist as such for a definite period of time during which the dehydrogenated substrate dissociates from and the electron acceptor of the next stage becomes attached to the enzyme? Or can the electrons removed from the substrate be transferred *directly* to an acceptor fixed to a different point on the enzyme, this process occurring before or during the dissociation of the oxidized substrate?

Michaelis (1935) has suggested that oxidations of organic molecules proceed by successive univalent (one-electron) steps. It is to be noted, however, that the reduction of the pyridine and isoalloxazine systems has generally been written as shown above, involving two electrons and giving rise to dihydro compounds. Formally, the initial dehydrogenation of a substrate could be written in two ways:

$$\begin{aligned} SH_2 + E &\rightleftharpoons SH + EH \\ SH + EH &\rightleftharpoons S + EH_2 \\ EH_2 + S' &\rightleftharpoons S'H + EH \\ EH + S'H &\rightleftharpoons S'H_2 + E \end{aligned} \qquad \text{I}$$

overall: $SH_2 + S' \overset{E}{\rightleftharpoons} S + S'H_2$

or

$$\begin{aligned} SH_2 + E &\rightleftharpoons SH + EH \\ EH + S' &\rightleftharpoons S'H + E \\ SH + E &\rightleftharpoons S + EH \\ EH + S'H &\rightleftharpoons S'H_2 + E \end{aligned} \qquad \text{II}$$

overall: $SH_2 + S' \overset{E}{\rightleftharpoons} S + S'H_2$

Where SH_2 = substrate being dehydrogenated;
S' = substrate being reduced (electron acceptor);
SH, S'H = substrates after gain or loss of one electron;
E = enzyme;
EH = enzyme reduced in a univalent step;
EH_2 = dihydroenzyme.

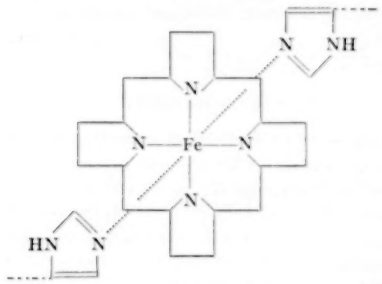
In short, does an enzyme such as coenzyme I (Co·I) ever reach a discrete $CoH_2 \cdot I$ stage in the living cell (for it can be made to do so in vitro)? or is it reduced to the free-radical stage (CoH·I) only, and does it then, by liberation of this single electron to the next substrate, revert to the Co·I stage before removing the second electron from the initial substrate?

It will be shown in the sequel that there are reasons to prefer scheme II for the overall process. It will remain to be demonstrated how such an assumption can account for the facts of enzyme catalysis.

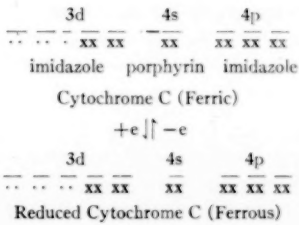
One of the most compelling reasons to adopt scheme II (transfer by one-electron steps) lies in a consideration of that enzyme through which, in most living cells, most of the aerobic respiration is known to pass. This is cytochrome C, for which the process occurring in the oxidation-reduction reaction is the reversible reduction of the iron atom in the porphyrin-protein complex:

$$Fe^{+++} + e \rightleftharpoons Fe^{++}$$

Theorell (1941) has proposed a model for the cytochrome C molecule in which the iron atom is bound to the four porphyrin nitrogen atoms and to the imidazole rings of two histidine residues in such a way as to complete its octahedral coordination sphere, and the histidine residues are part of the protein moiety of the enzyme:



The cytochrome C—reduced cytochrome C change may be pictured in detail (referring only to the outer, or valence, shells of the iron atom) as follows:



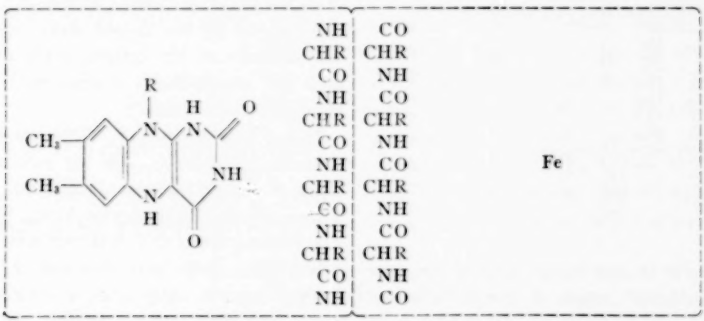
The iron atom, which receives and passes on electrons in performing its function in the oxidation-reduction series of which it forms a vital part, is thus seen to be completely imbedded in a matrix of protein. That it is not directly accessible to other atoms or groups which commonly attack iron-porphyrin complexes (such as hemoglobin, cytochrome oxidase, catalase, etc.) is shown by the fact that it is not auto-oxidizable and does not combine readily with such substances as the cyanide ion (Horecker and Kornberg, 1946) or carbon monoxide at physiological pH values. It would therefore appear improbable that a substrate (e.g., the cytochrome-reductase prosthetic group) could become so disposed sterically that a *direct* transfer of electrons could take place to the iron atom.

How, then, does the electron gain access to the 3d shell of the iron atom? Since there can be little doubt that the protein component of the enzyme plays an important part in the process of electron transfer, it may be suggested that the structure of the protein molecule is uniquely constituted to provide for the transfer of electrons from a substrate (e.g., cytochrome reductase) to the iron atom, and from the latter to an oxidant (e.g., cytochrome oxidase).

THE NATURE OF THE PROTEIN MOLECULE

An abundance of experimental evidence exists to support the view that many protein molecules do not exist in the form of extended polypeptide chains, but form compact, globular units which arise by the folding or coiling of the chain. The nature of the forces which hold the molecule in that configuration characteristic of the particular protein has been a matter of controversy, but a number of students of this question appear now to agree (Bull, 1941) that the hydrogen bond plays an important part in fixing the final configuration of the molecule by tying adjacent portions of the folded chain together. According to this view, the protein molecule may be viewed as a particle, the surfaces of which are composed of a mosaic of —NH,—C=O, and R groups (where R represents the "side-chains" of the constituent amino acids), and the interior of which consists of a complex, three-dimensional matrix of the same groups (and probably of water molecules also).

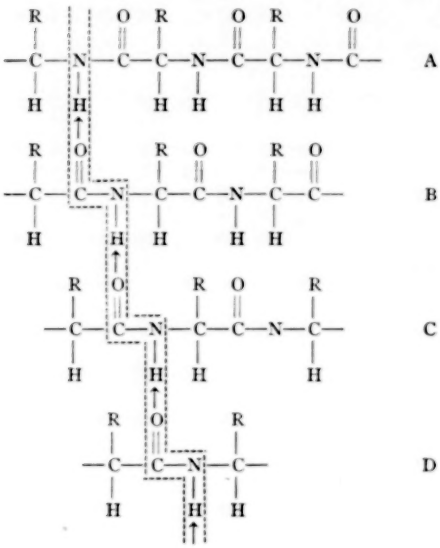
The nature of the cytochrome C molecule is such that it can be assumed that the iron atom is imbedded in the protein matrix, and that the only points of contact with the substrate from which electrons are derived are between the substrate and the protein surface. Indeed, an equally acceptable view is that *the actual contiguity is between two protein surfaces*, both the prosthetic group of the substrate (e.g., cytochrome reductase) and the iron atom being separated by an intervening screen or film of portions of the protein matrices. A diagrammatic representation of this is as follows:



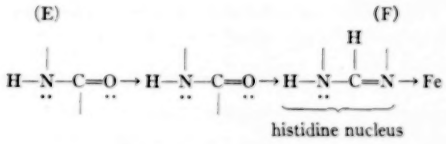
In either case, it is possible to formulate an answer, in *general* terms, to the question posed above: how do electrons reach the 3d shell of the iron atom? It is that the electrons are *transmitted to the (ferric) iron atom through the protein matrix, and likewise transmitted away from the (ferrous) iron atom through the protein matrix* in the next step of their passage to, eventually, oxygen. The expression of this concept in specific terms and its application to other members of the respiratory enzyme complex constitutes the hypothesis with which this discussion is concerned.

THE ROLE OF THE PROTEIN IN ELECTRON TRANSMISSION

The unique feature of the protein molecule is the polypeptide chain, which has as its characteristic feature the repeating HN—C=O unit. This unit forms a system uniquely capable of uniting polypeptide chains, or contiguous sections of the same (folded) chain, by means of hydrogen bonds (which may include water molecules). This bridging may be represented as follows (Huggins, 1940):

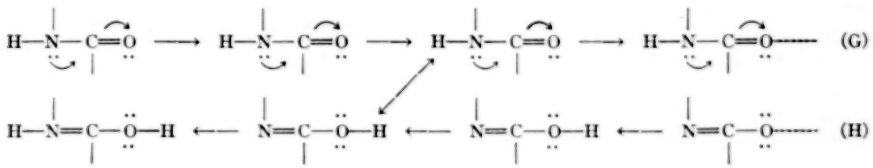


A, B, C, and D may be (a) parts of the same protein "backbone" which is folded back and forth upon itself; or (b) parts of separate polypeptide chains that form parts of separate "backbones." Analogs of the peptide linkage in the "ammono" system, such as the HN—C=N— grouping in the histidine molecule, are formally and functionally equivalent to the HN—C=O linkage. In the case of cytochrome C, the iron atom, which is surrounded by a protein "atmosphere," forms the terminal unit of a hydrogen-bonded chain of HN—C=O units, the last of which, according to Theorell's model, is the imidazole-Fe bond. The essential system may be pictured:

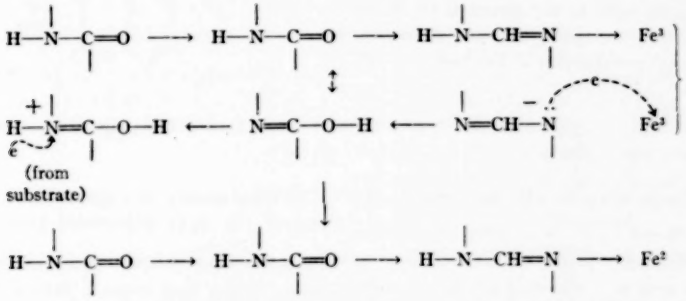


The reduction of Fe^3 to Fe^2 would thus be accomplished by a direct transfer of an electron from the nitrogen atom bonded to the iron (point F) accompanied by the release of an electron from the substrate to the bridged chain at point E, and the simultaneous readjustment of bonds throughout the system.

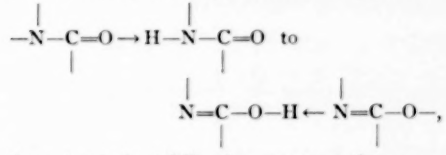
It is a further postulate of the present scheme that the bonds involved in the hydrogen-bonded chain of peptide linkages can exist in states comprising the resonating system represented by the two extreme forms G and H. Schmitt (1947) and Wirtz (1947, 1948) have discussed the hydrogen-bridged protein chain from a similar point of view, and have offered further arguments to support this concept:



While it may at first appear that the absence of direct evidence for resonance of this sort represents a defect in the hypothesis, it is probable that this difficulty is more apparent than real. For one thing, formal electron shifts such as those in G and H represent a *capacity* of the system shown when operating as a part of the complete [substrate$_1$—enzyme—substrate$_2$] system, and not necessarily a permanent property of the isolated enzyme; and, further, because of the possibly enormous number of such peptide units linked together as in G, the number of possible forms that can be written for the system may be so



arge that even though small energy barriers may have to be surmounted for each change from



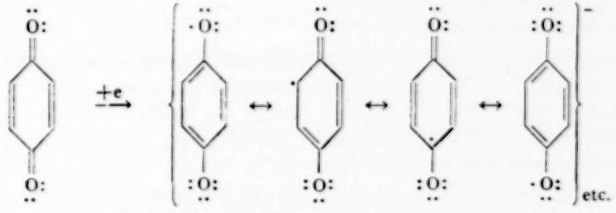
the net gain in stabilization may more than overcome the required expenditure of energy.

The transfer of an electron in the cytochrome C system, bringing about the change

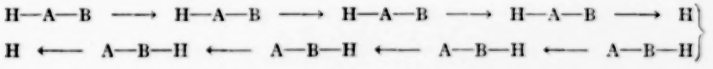
$$e + Fe^{+++} \rightarrow Fe^{++}$$

would then be represented in the following way. The imidazole unit with which the iron atom is coordinated, and at which electron release to the metal takes place, is considered to be located somewhwere in the protein matrix; the H—N— group to which electron release from the substrate occurs may be on the protein surface at the place to which the substrate is "attached":

It appears to be significant that similar considerations make it possible to apply these basic concepts to at least two other important members of the respiratory enzyme chain, the pyridine and isoalloxazine prosthetic groups. Before discussing these systems, however, it is of interest to point out the analogy of the process of electron transfer in such systems with that involved in the reduction of a quinone with the formation of a semiquinone.



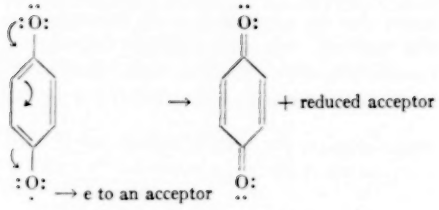
Support for this concept of the nature of the bridged chain of peptide linkages is found in the work of Hunter (1945), who regards systems of this sort as completely degenerated into the form expressed by the generalized system J:



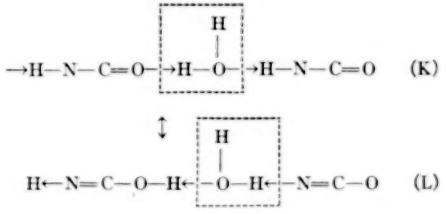
(J)

Removal of an electron from the semiquinone by some hypothetical acceptor could be formulated in a way that demonstrates the similarity in the reactions, and shows how the process can be represented as the "feeding in" of an electron at

one point and the "feeding out" of an electron at another:



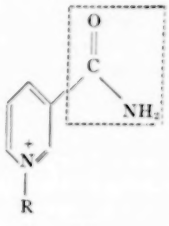
If the peptide units in the system G ↔ H are bridged indirectly by means of water molecules, no fundamental modification of the basic concept is necessary:

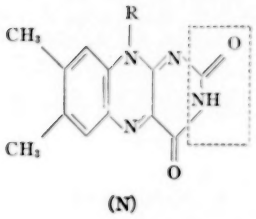


In such a case the "identity" of the protons concerned in the bridges is lost, the "water molecule" being as in (K) in one case and as in (L) in the other.

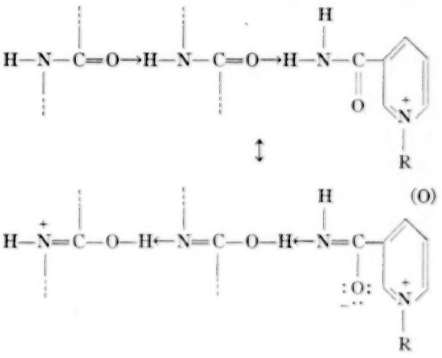
APPLICATION TO OTHER PROSTHETIC GROUPS

It appears to be significant that other prosthetic groups found in dehydrogenase enzymes can be dealth with in an entirely analogous way, and it would appear to be more than coincidence that a number of these, and in particular the phosphopyridine and isoalloxazine nucleotides, possess as integral and probably indispensable parts of their structure the amide grouping, $O{=}C{-}N{-}H$ (Kuhn and Rudy, 1936). These are shown in (M) and (N), the amide groupings being outlined in the formulas:

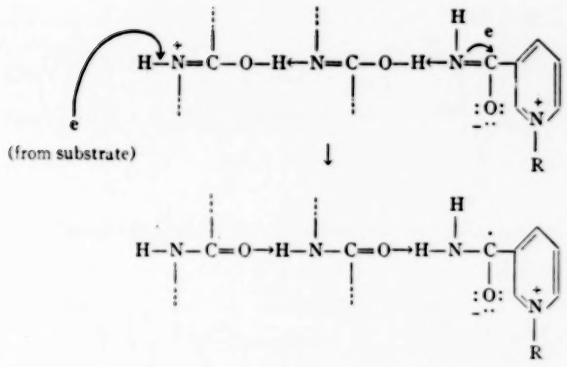




In these cases it is suggested that the $-C{=}O$ end of the hydrogen-bonded peptide chain is bonded to the $H{-}N{-}$ group of the prosthetic group, which thus forms a part of the chain of bridged peptide linkages. The complete system that includes coenzyme I (or II) would then be formulated as follows (O):

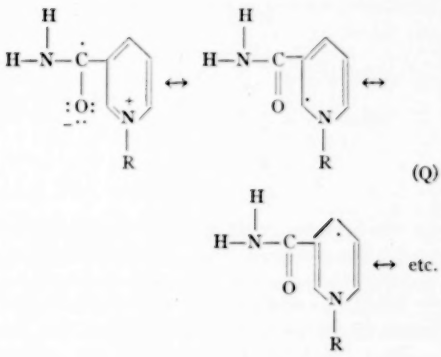


The "transmission" of an electron down this system from left to right involves the same process as is discussed above. Assuming a single electron change, the result of such a process would be a semiquinone-like form of which one state may be represented as follows (P):



(P)

The free-radical-like, reduced nicotinamide nucleus can be represented as a hybrid of a number of resonating forms, shown in (Q):



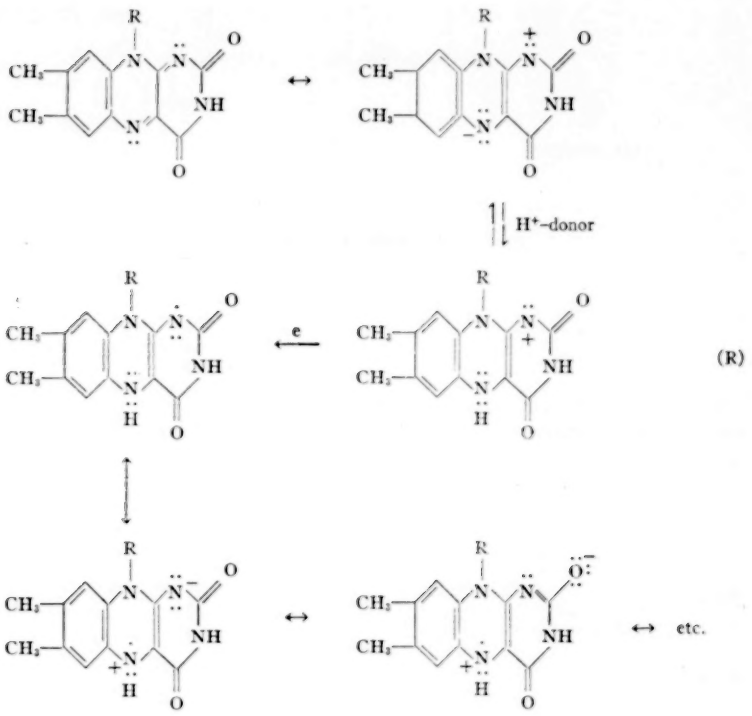
(Q)

It is a fundamental part of the present hypothesis that the resonance energy associated with such a semiquinone-like intermediate stabilizes the system (substrate-protein-prosthetic group), lowering the activation energy associated with the removal of the first electron from the hydrogen donor, and in this way explaining the catalytic effect of the enzyme in causing reactions to proceed at useful rates under physiological conditions of temperature and pH.

These considerations raise the following question: since the greater part of the respiratory hydrogen transport passes through the cytochrome system, in which only a one-electron change is possible, is it necessary to consider the reduction of Co·I or Co·II as proceeding in a two-electron manner, as it is commonly formulated? Or is it reduced to the free-radical stage only, and then changed back to the oxidized form by the second (electron-accepting) substrate? Reaction series II, p. 8, is referred to in this connection. In short, since cytochrome C *cannot* undergo a two-electron change, it is appropriate to ask whether coenzymes I and II *need to.*

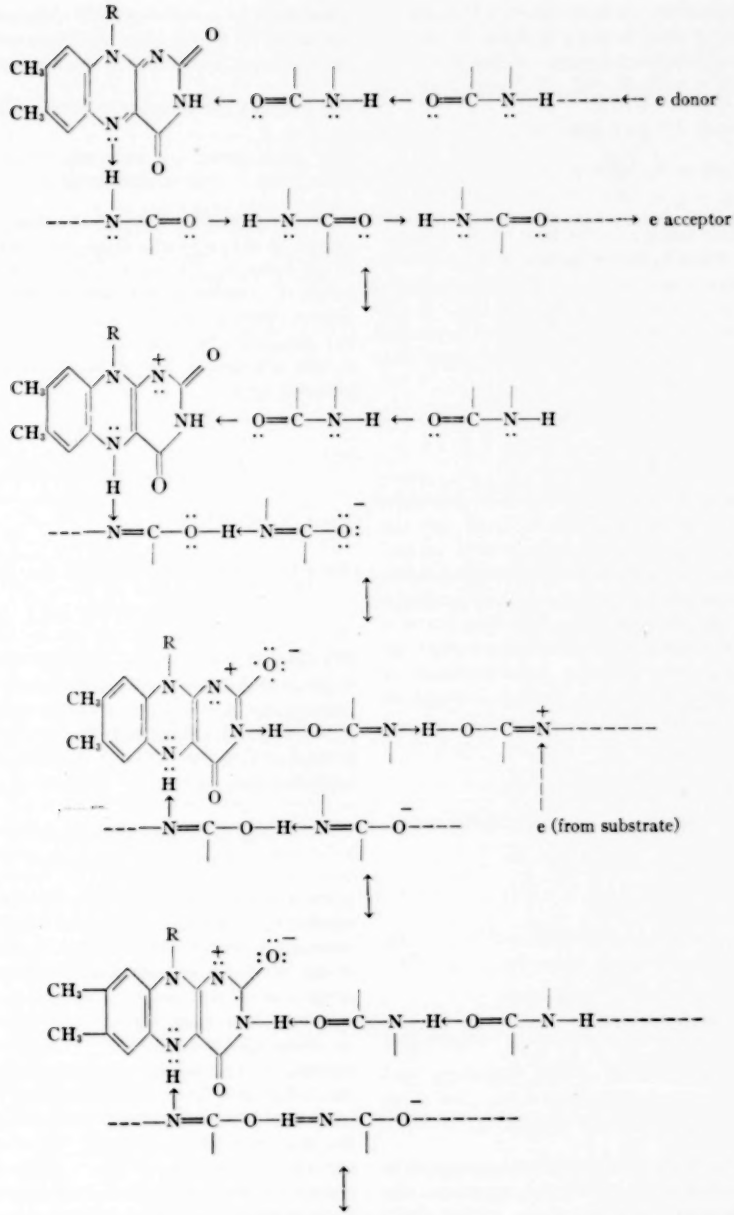
A further point of similarity between the cytochrome C-protein system and the pyridine-protein system may be mentioned. Cytochrome C, according to Theorell (1941), has two imidazole nuclei coordinated with the metal atom. One of these may be the point of discharge of an electron to the the iron, and the other its point of departure, through a second peptide-linked chain, to some point on the protein surface from which it is passed on to the next receptor. Similarly,the nicotinamide nucleus contains two amide hydrogen atoms. This could mean that it is associated with two separate hydrogen-bonded peptide chains, one "feeding" electrons in to the pyridine nucleus, the other feeding them out to another point on the protein to which an electron acceptor may be bound.

The systems that involve isoalloxazine derivatives as prosthetic groups may be treated in a strictly comparable manner. Here the overall process, leading to the semiquinone or free-radical form, may be pictured as follows (R) (cf. LuValle, 1948):

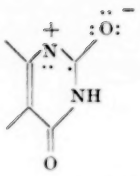


Again, as in the cases of cytochrome C and the pyridine enzymes, a second point of attachment is present, by means of which a second chain of peptide linkages might permit the odd-electron to be transmitted to an electron acceptor. This is the —NH— group in the central ring. The assumption is made that this group is formed by association of a proton with the oxidized form of the isoalloxazine nucleus. It is further suggested that the source of this proton is an —NH— group present in the efferent HNCO—HNCO—HNCO——— chain. These assumptions appear to be justified for two reasons. First, it has been shown that the semiquinone form of the reduced isoalloxazine nucleus is detectable only in acid solution, or when the complete enzyme is present (Haas, 1937). This implies that the negatively-charged semiquinone is too unstable to be formed (cf. the influence of pH upon the stability of the semiquinones derived from *p*-phenylenediamines) and that the protein is as capable of donating a proton as is an acidic reaction medium. The second reason for the assumptions made is that while the oxidized isoalloxazine prosthetic group is dissociable from its protein, the reduced form is not. This implies that in the reduced form a second link has been established between the nitrogen atom of the central ring and the protein. When the reduced (i.e., the semiquinone) form of the enzyme exists, it does so only as a member of the complete system: substrate$_1$ + enzyme + substrate$_2$. The bond in question, then, is not one between two distinct systems, but one of those present in a single, integrated system. In the oxidized form this linkage, if it exists, is one of simple association and is easily broken.

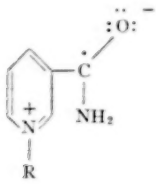
The place of the protein in enzymes containing isoalloxazine nucleotides would then be pictured as follows:


e donor
e acceptor
e (from substrate)
forms as in formulas (R)

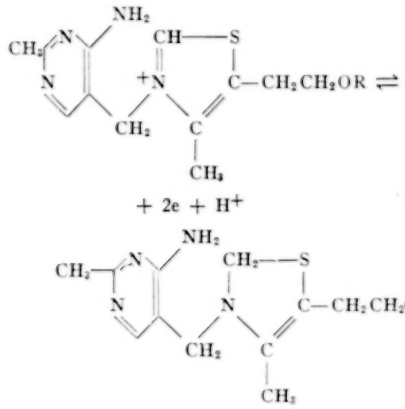
The system



bears a close analogy to the form which arises at the same stage in the reduction of the pyridine system:



The isosteric relationship between the thiazolium ring of the thiamine molecule and the pyridinium ring of the phosphopyridine nucleotides makes it an attractive hypothesis to suppose that enzymes which contain the thiamin prosthetic group act as dehydrogenases. That such enzymes are indeed concerned in oxidation-reduction reactions (e.g., the oxidative decarboxylation of α-keto acids) is well-known. There is, however, no evidence that the reversible change (S)

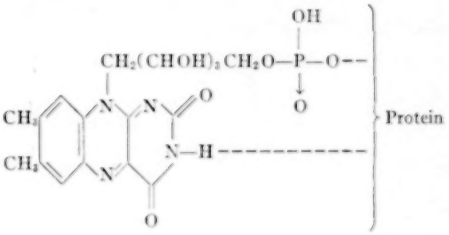


occurs in metabolic reactions. In view of this, there is no experimental basis for applying the mechanism discussed above to this system. It is, however, to be noted that the thiamin system does contain all of the structural requirements for attachment to a linked peptide chain and for the formation of a resonance-stabilized semiquinone state. It, too, is an amide of the ammono system,

and contains the grouping $-N=C-NH_2$.

THE ATTACHMENT OF THE PROSTHETIC GROUPS TO THE PROTEIN

The "essential" points of attachment of the protein to the prosthetic group have been defined in the foregoing discussion. That there are other points of attachment has been suggested by numerous investigators. For instance, Kuhn (1936) has proposed that the isoalloxazine nucleotide-protein complex in the yellow enzymes is of the following type:



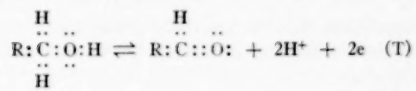
The present hypothesis defines the nature and function of the bond between the protein and the imino group, and suggests a further point of attachment in the central ring. Similar remarks can be applied to the cytochrome C and the pyridine nucleotide systems.

THE ROLE OF THE PROTEIN IN SUBSTRATE ACTIVATION

On the basis of the above hypothesis it is possible to assign to the protein a specific role in substrate activation. The question of the function of the protein in bringing about such an "activation" has always been fundamental to the consideration of enzyme action, but the mechanism by which this is brought about has never been expressed in any but general terms and it has not been directly related to the unique structural features of the protein molecule. It will be shown that the essentials of substrate activation can be formulated in specific terms by the use of the concepts already applied to other phases of the electron-transfer process.

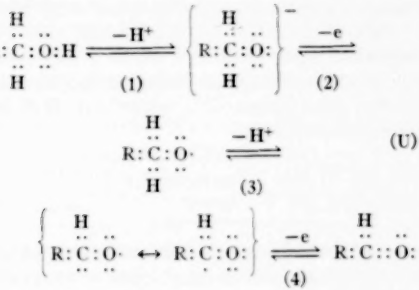
To choose a simple example for the illustration of the conditions to be met and the manner in

which they are fulfilled, consider an alcohol dehydrogenase reaction (T):



(T)

For purposes of illustration, and in keeping with the overall scheme so far developed, this reaction may be represented formally in the following way (U), with the provision that some of the steps written as being consecutive may occur simultaneously:

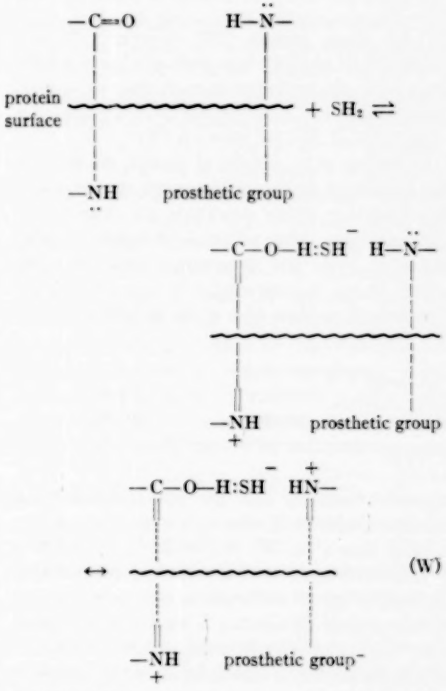


(U)

The largest energy barrier in this series of reactions is probably in steps (1) and (2), since the transfer of an electron from a free radical, such as that resulting from step (2), is a process that requires little activation energy (Hammett, 1940). The anion RCH_2O^- and the free radical derived from it are incapable of resonance stabilization, but step (4) leads to the aldehyde, in which a certain amount of such stabilization is possible. The necessary conditions would thus appear to be two: (1) ionization of the alcohol molecule as a first step; and (2) provision of a means for the stabilization of the transition state leading to the initial radical. Kalckar (1946) has discussed this reaction from a similar viewpoint and has drawn a similar conclusion. It is perhaps not proper to consider steps (1) and (2) as distinct and consecutive, but it is convenient and permissible to treat them as such for the purpose of analysis.

There is ample reason to suppose that the initial removal of a proton is necessary for the ready release of an electron in the first oxidation step. The nature of the protein structure and the mode of attachment of the substrate to the protein offer a basis for the following proposal of how these conditions are fulfilled.

The nature of the attachment between the protein and the prosthetic group has been discussed in detail. It would be a consequence of the mechanism proposed for electron transmission to the prosthetic group that the substrate is bonded to the —NH end of the bridged peptide chain, just as the electron acceptor is attached to the —C=O end. It can be supposed that at some particular ("specific") point on the protein surface there exist a —C=O and an —NH group of different peptide-linked chains in such a steric relationship and in such an environment that the following interaction between these and the substrate molecule (SH_2) is possible:



(W)

The "specificity" of this area of the protein surface can be assumed to result from the particular steric relationships between the amino acid side-chains, the contiguous —NH and —C=O groups, and the substrate. "Specificity" must then be regarded as making enzymic reactions *possible*, rather than as *causing* them to occur.

The situation shown in the last stage of the

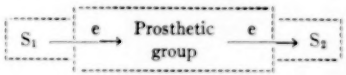
above series is now uniquely favorable for the sequence of steps leading to a transfer of an electron to the prosthetic group in the manner already outlined. *The ionized substrate is present and it is in a unique steric relationship to the end of the polarized peptide chain leading to the prosthetic group.*

The possibility has been considered by Kalckar that another kind of resonance stabilization may be involved in the free radical, ·SH, which is formed in the first electron transfer step. If two substrate molecules are simultaneously undergoing dehydrogenation at suitably contiguous points on the enzyme, the free radical may be stablized by a three-electron resonance of the following sort:

$$(HS\cdot + :SH)^- \leftrightarrow (HS: + \cdot SH)^- \qquad (X)$$

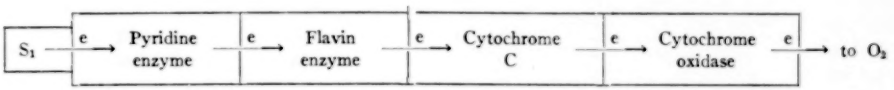
In the above picture, (W), however, the free electron pair of $:SH^-$ is in hydrogen bond equilibrium with the hydrogen atom of the =C—O—H residue, and would not appear to be available for interaction of the kind shown in (X).

A further characteristic of protein structure to be considered is the arrangement of the amino acid residues which constitute its "backbone." Evidence has been adduced (Bergmann, 1938; Astbury, 1943) and no contrary evidence exists which makes it unreasonable to suppose that the amino acid residues of a given protein chain are repeated regularly and are not scattered in a random fashion. If the active portion of the protein shown in (W) is specific by virtue of a peculiar arrangement of side-chains, it is probable that such "spots" will occur in each repeated unit of the protein backbone. Some of these regions may be unavailable because of the manner in which the protein is folded, but it is reasonable to suppose that a protein may have on its surface more than one, and perhaps many, regions specific for a given substrate. This would lead to the supposition that the prosthetic group may not be uniquely linked (as in formula O) to *one specific end-group* on the protein surface, but that by virtue of possible cross-linking through a complex hydrogen-bonded matrix *it may receive electrons from more than one —NH end group* and thus from more than one substrate molecule, not simultaneously, but certainly more rapidly than if only one specific spot were acting through diffusion of oxidized and reduced substrate molecules to it and away from it. Such a concept is not inconsistent with the suggestions made above that electrons may enter a protein at one point on its surface and leave at another. The system as a whole may then be generalized as follows:

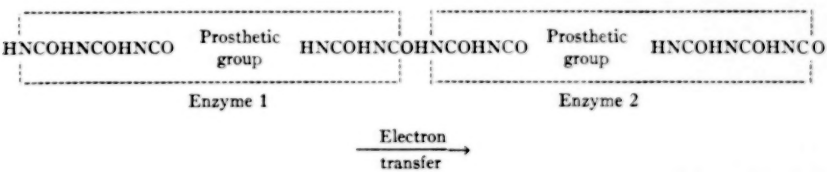


S_1 = substrate being oxidized (electron donator).
S_2 = substrate being reduced (electron acceptor).

If we apply this idea to that of the "proteon" or macromolecule (Green, 1948), a coupled series of oxidation-reduction enzymes could be pictured as follows:



In such a system, the linkage from each enzyme to the next would be through peripheral —C=O bridges, the —C=O being a part of the protein of the enzyme furnishing the electron, the —NH being a part of the enzyme accepting it The system could be represented as follows:



ACTIVATION AND DEACTIVATION OF ENZYMES

Enzymes of many kinds, including many that are not concerned directly in oxidation-reduction processes, can be activated and inhibited by a wide variety of treatments and chemical substances (Sumner and Somers, 1947). Inactivation by heat and other means of denaturation is readily understandable in terms of the present hypothesis, since it is generally accepted that denaturation involves a disruption of the structural integrity of the native protein and the establishment of new interatomic linkages. Certain other kinds of inhibition or deactivation are well understood. Among these are the inhibition of metallo-porphyrin enzymes by such substances as the cyanide ion, and the inhibition of other enzymes by reagents which react with —SH groups in the protein (or with —S—S— groupings, by transforming these into —SH).

What is less clear in examples of the last-mentioned kind is the function of the —SH groups in the active enzyme and the reason why their modification into —SR or —S—S— causes a loss of activity. It is important to note that this deactivation is associated not only with oxidizing enzymes, but with hydrolytic enzymes, e.g., urease (Sumner and Somers, 1947), as well. This would appear to dispose of the probability that the activity of sulfhydryl groups lies in their ability to form one of the links in a hydrogen-transport system by undergoing the change

$$R{-}SH \rightleftharpoons R{-}S{-}S{-}R + 2H^+ + 2e,$$

and further suggests some fundamental similarity, with regard to the protein component, between the mechanisms of action of oxidative and other (e.g., hydrolytic) enzymes. It should be reemphasized here that the suggestion is not made that the change $2{-}SH \rightarrow {-}S{-}S{-}$ does not occur, but only that this change does not constitute a step in the chain of electron transfer.

The action of chemical agents upon sulfhydryl groups can be considered from the standpoint of their effects upon the S—S distance.

1. Oxidizing and reducing agents can bring about the reaction

$$-SH + HS- \rightleftharpoons -S-S-$$

modifying the S—S distance from that which is at least the sum of two S—H bonds plus the van der Waals distance between the hydrogen atoms, to one which is the —S—S— bond distance, or vice versa.

2. Metals may act as oxidation catalysts, thus bringing about the change described in (1); or they may act as complex-forming agents (Pirie, 1931), to bring about the changes

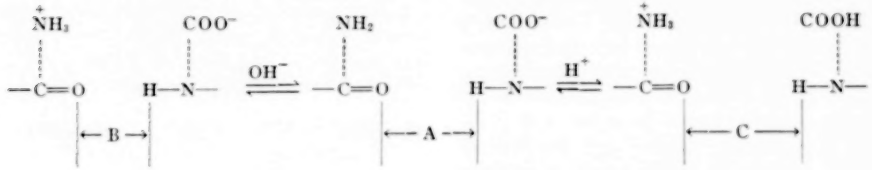
a) $-SH + HS- + M^{++} \rightleftharpoons -S-M-S- + 2H^+$, or

b) $-S-M_1-S- + M_2^{++} \rightleftharpoons -S-M_2-S + M_1^{++}$ (metal interchange)

It must be assumed that in the protein matrix the orientation of the various backbones, or of the sections of a single backbone, is influenced by the nature and disposition of the side-chains. If it is assumed that the relative positions of pairs of sulfhydryl groups in the side-chains are important orienting influences, then the critical nature of the effects of reagents upon these groups can be understood. In the active enzyme, under optimum conditions, the present hypothesis would make it reasonable to suppose that a *critical orientation of the "active" NH—CO pairs in the hydrogen-bonded peptide chain exists.* If, moreover, this critical orientation could be achieved only by maintaining interacting —SH groups in a *particular* spatial relationship, either by the formation of —S—S— linkages or metal complexes, or by the maintenance of conditions which prevent —SH groups from forming such bonds, then the effect of the agents which cause or reverse these reactions upon enzyme activity also becomes understandable.

Similar considerations can be applied to the well-known effects of pH changes upon enzyme action. The ionization of amino and carboxylic acid groups would bring about reversible changes in interionic forces which would change the relative orientation of contiguous portions of the protein matrix. Within a relatively small range of pH these changes in distance would probably be smooth and reversible, and at some definite pH the orientation of the protein skeleton in the neighborhood of that portion of the surface at which the "active" ends of the peptide chain were available to the substrate would be such that maximum activity would be observed. A generalized, diagrammatic picture of these changes

might be as follows, where the dotted lines are used to indicate portions of the protein molecule:



The distances A, B, and C are each different; of these, one is assumed to be optimum for a given enzyme (say A), and thus a rise or a fall in pH would cause the distance to change to B or C, distances which are less effective. This obviously could account for the typical pH-activity curves of enzymes.

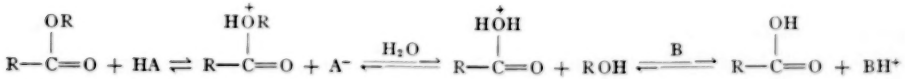
The generality of the discussion in this section is necessitated by the complete lack of information which exists concerning the fine structural details, not only of the "active" centers of the enzyme, but also of the native protein molecule as a whole. It would be a defeatist conclusion, from all that has been said already, to hold that little is to be learned about the true (chemical) mechanism of protein action by studies of such gross aspects of protein chemistry as molecular size and shape, and by proximate analyses in terms of the chemical units of which proteins are constructed. It would appear that studies at the atomic, rather than the molecular, level are needed to furnish answers to these questions.

HYDROLYTIC ENZYMES

From the foregoing discussion it is clear that the basic concept of the present hypothesis is an essentially simple one, and that its application to a number of the known facts of enzyme action requires only a demonstration of how the various factors which influence enzymic reactions affect the integrity of a chain of hydrogen-bridged peptide groupings maintained in an optimal steric orientation. It is further suggested that the same properties of the linked chain of peptide groupings which allow it to act in an electron-transfer process can be used to account for enzymic reactions involving hydrolytic processes.

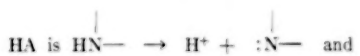
Non-oxidative enzymatic reactions appear to fall into the single broad class of acid-base catalysed reactions. The hydrolysis of esters and amides, the formation and disruption of glycosidic linkages, and condensations of the aldol and reverse-aldol type are all clearly of this kind, and are among the more conspicuous of enzyme reactions. It would thus appear that the peculiar ability of enzymes to aid in bringing about enzymic reactions lies in the ability of the protein to act as an effective acid-base reagent, and that this ability depends upon the protein's capacity for stabilizing intermediate, or transition, ionic states by the distribution of a charge over the long hydrogen-bridged peptide chains.

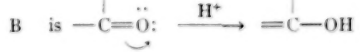
As an example, consider the action of an esterase. The acid-catalysed hydrolysis of an ester can be formulated mechanistically in the following (somewhat abbreviated) way:



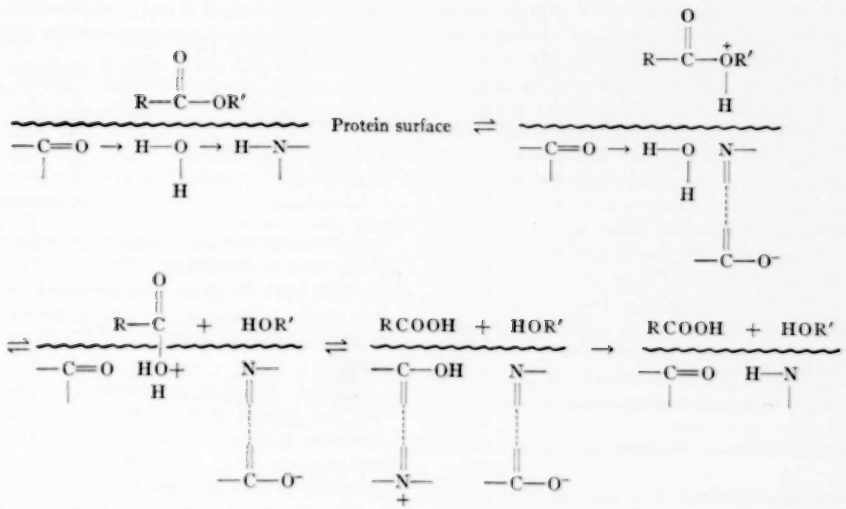
where HA and B are a generalized acid and base

It is now suggested that in the enzyme,





For the action of an esterase, the following scheme is suggested:



In this reaction the water molecule involved in the reaction is shown as a component of the protein, as in formulas (K) and (L), p. 316. This is not a necessary assumption, however, and is included simply to show how such water might play a part in hydrolytic reactions. For amidase or peptidase action the replacement of —OR by —NH_2 or —NHR allows the same sequence to be written. If the power of the protein to act as an effective acid-base system is assumed, its ability to bring about glycolyses, aldol condensations, and like reactions becomes understandable.

It is impossible to be more explicit regarding the differences between enzymes which hydrolyse esters and amides, those which hydrolyse glycosides, and those which catalyse aldol-type reactions. It is probable, however, that these differences reside in the same realm in which are found more specific differences, such as those between enzymes that are specific for different esters or different glycosides. These differences may lie in the dispositions of the non-peptide portions of the protein at the site of reaction, which allow particular substrates to approach the particular —N—H ← O=C— residues at which reaction is brought about.

It would be the conclusion from the above discussion that enzymatic *specificity* is a matter quite distinct from the *mechanism* of enzyme action. Specificity is a condition which *allows*, not *causes*, a given substrate to react. There appears to be no need to elaborate upon the bearing of this conclusion upon the question of the inhibition of enzymic reactions by substances that bear a structural analogy to the normal metabolite.

INCIDENTAL OBSERVATIONS

The hypothesis has been advanced that substances which are found in traces in the cell and which are necessary to the organism in trace amounts exert their effects by action upon or participation in some enzyme system. Although the definition of the term "trace" is an arbitrary one (Green, 1941), this idea might be extended, with perhaps some exceptions, to substances that in general have a physiological effect in small amounts (relative to the size of the organism), and thus be broadened to include, besides vitamins, hormones, and trace poisons, the general class of substances known as drugs.

Some enzyme inhibitors act by specific inhibition of the prosthetic group (e.g., cyanide in the case of metalloporphyrins, BAL in the case of tyrosinase, etc.); some, by competitive inhibition, probably at the protein surface, by reason of structural analogy; some, by interaction with essential sulfhydryl groups or essential disulfide linkages; some, by inducing changes of other kinds (e.g., denaturation) in the protein; while the manner in which certain others act is unknown.

In terms of the hypothesis of enzyme action so far developed, it is clear how it is possible to arrive at a general understanding of how serious impairment of enzyme action can be caused by minute traces of inhibitors. If the essential integrity of the enzyme is that of the relative spacing of that part of the protein molecule in the region of the "active" center, any influence that changes this spatial relationship will affect the activity of the enzyme. There are three ways in which an interfering substance might act directly upon an enzyme system, other than the fairly well understood effect of substances which inactivate prosthetic groups, react with sulfhydryl groups, or denature proteins irreversibly:

1. The drug may interrupt the normal transmission system of the hydrogen-bonded series of peptide links by changing an essential $-\mathrm{N}-\mathrm{H}\cdots\mathrm{O}=\mathrm{C}-$ distance or by actually forming a link in the essential chain.

2. The drug may compete with a metabolite or other substrate for that portion of the protein surface at which electron transfer occurs.

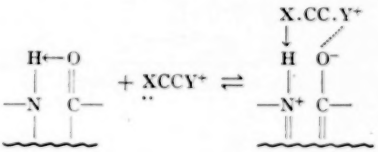
3. The drug may replace the prosthetic group at the end of the —HNCOHNCOHNCO—chain.

It is not be inferred that drug action is invariably concerned with an interference with oxidation-reduction processes. It has been explicitly stated in the present discussion that an extension of certain of the fundamental postulates of this hypothesis makes it possible to correlate non-oxidative enzyme action with other kinds of enzyme action upon the basis of the concept of the hydrogen-bonded peptide chain. Consequently, the effects of drugs which do not act directly upon the prosthetic group itself can be rationalized *if the integrity of a specific peptide-linked chain is fundamental to enzyme action of all kinds.*

It is significant that many well-known drugs are amides, amines, or ammonium salts in which a slightly basic (oxygen, aryl nitrogen, etc.) atom is present in the molecule. The possible role of an amide in forming a "counterfeit" link in a chain of peptide units is obvious. In a drug having the general structure

$$\mathbf{X}-\mathrm{C}-\mathrm{C}-\mathbf{Y}^{+}$$

where $\mathbf{Y}^{+}$ is an ionized $-\mathbf{NR}_2$ group or an $-\mathbf{NR}_3^{+}$ group, and **X** is a donor atom such as —OR, —SR, $-\mathbf{NR}_2$, (one **R** is aryl), —NH—COR, etc. the combination with a protein could be pictured:



Such a combination could result in (1) a disruption of a chain —HNCOHNCOHNCO— in which the NH and CO groups shown above were a unit, or (2) in changing the spacing between the backbones in which the NH and CO groups were present.

Countless examples of possible interactions of this and related kinds could be suggested as attractive speculations. Suffice to say that they form another body of evidence to support the hypothesis that the hydrogen-bonded peptide chain is of fundamental importance in the mechanism of enzyme action.

SUMMARY

A hypothesis of the mechanism of enzyme action has been developed, which accounts for the participation of the protein component in enzymatic reactions in terms of its molecular structure.

The fundamental postulates of this hypothesis are:

1. The process of electron transfer involves the participation of a hydrogen-bridged chain of peptide linkages in the transmission of electrons from substrate to prosthetic group.

2. Hydrolytic enzyme reactions are essentially acid-base catalyzed reactions in which the hydrogen-bridged chain of peptide linkages plays the role of proton donor and acceptor.

Based upon these postulates, the role of the prosthetic groups of oxidation-reduction enzymes is discussed in terms of one-electron changes and the participation of semiquinone intermediates.

Upon the fundamental postulate that enzyme action depends upon the steric integrity of a specific hydrogen-bridged chain of peptide linkages, suggestions are made concerning the activation and inactivation of enzymes, the role of sulfhydryl groups, the effects of pH changes, and the action of drugs and other trace substances.

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THE FUNCTIONS OF TYROSINASE IN INSECTS

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DURING the course of an investigation of the physiological and biochemical effects induced by a parasitic fungus upon its insect host, it was found that the blackening of the insect's blood was one of the most characteristic expressions of the disease. Such blackening is due to the presence in the animal's blood of tyrosinase which catalyses the reactions leading to the formation of melanic pigments. This enzyme is widespread in nature, and its chemistry has been extensively studied in both plants and animals (cf. review articles by Kastle, 1910; Raper, 1932; Sutter, 1936; Oppenheimer, 1939; Nelson and Dawson, 1944; Dawson and Mallette, 1945). However, there have been no comprehensive recent reviews of the physiology of the action of tyrosinase in insects, except for a short one by Wigglesworth (1947), and so the writer has felt that such a review would serve to relate the older literature to some of the more recent findings in the field.

HISTORICAL INVESTIGATIONS OF TYROSINASE

That the blackening of insect blood is a catalytic reaction induced by certain components of the blood of insects has long been recognized. As far back as 1881, Fredericq observed that the blood of *Oryctes nasicornis* (Coleoptera)) fails to darken in air when heated to 50–55°C for ½ hr., and in 1886 Krukenberg suggested that CO_2 is responsible for the changes in the color of the blood of *Hydrophilus* (Coleoptera) and certain molluscs. But neither of these investigators understood the full significance of this organic catalysis, so that further progress in this field had to await the demonstration of enzymes in vitro by the Büchners in 1896 and the discovery of tyrosinase in plants by Bourquelot and Bertrand (1895). These advances led directly to the discovery of a tyrosinase of animal origin, in *Tenebrio* (Coleoptera) larvae, by Biedermann (1898) and stimulated an extensive investigation of the chemistry and physiology of the blackening reaction.

It had been suspected even before the discovery of the enzyme that oxygen plays an important role in this reaction (Fredericq, 1881) but it remained for Biedermann (1898), Gessard (1904), Gortner (1910, 1911a, b), Przibram (1919), and others to prove this point by experimental means. These workers demonstrated that insects kept in vacuo, or in pure nitrogen, fail to become pigmented, while control insects kept in air develop their normal pigmentation. The paths available for the entry of the oxygen into the reaction in vivo were also investigated later, and it was found that this gas can be supplied via the blood (Tenenbaum, 1934), tracheae (Henke, 1924), or less frequently, the integument (Brecher, 1921). In contrast to these findings, it was found that in some cases pigmentation is inhibited when the insect is placed in an atmosphere of pure oxygen (Linden, 1905).

Since the role of oxygen had been elucidated and the enzyme characterized, it was next possible to formulate the overall reaction of the blackening process. This was postulated as being:

$$\text{oxygen} + \text{chromogen} \xrightarrow{\text{tyrosinase}} \text{melanin}$$

THE RELATION OF TYROSINASE TO OTHER OXIDASES

It soon became apparent that many different phenolic compounds can serve, in vitro, as the chromogen substrate for the enzymes which catalyse the formation of melanins. The early investigators were therefore led to name several different enzymes on the basis of the various compounds which they found to be oxidized by the material with which they worked. Hence, besides tyrosinase, such enzymes as dopaoxidase (Bloch, 1917; Hasebrock, 1921), catecholoxidase (Oppenheimer, 1939), diphenolase (Danneel, 1943), and polyphenolase (Batelli and Stern, 1913; Yamafuji, 1934) were described as occurring in insects. However, recent investigators (Nelson and Dawson, 1944; Mallette, 1945) have shown that mushroom

tyrosinase can catalyse the aerobic oxidation of both monohydric and ortho-dihydric phenols, so that this enzyme seems to be "one copper protein entity or complex possessing two enzymatic activities." From the work of these authors it is apparent that it is easy to overlook the phenolase (monophenolase) activity of tyrosinase, since the ability of this enzyme to oxidize monophenols is much more transitory than its ability to oxidize polyphenols. It is likely, therefore, that those enzymes in the insect which have been distinguished from tyrosinase solely upon the basis of their ability to oxidize polyphenols and their failure to oxidize monophenols will ultimately be found to be part of a single copper protein complex. The close association of these oxidases in certain physiological phenomena, such as the hardening of insect cuticle (Dennell, 1947) and the pigmentation of the elytra (Tenenbaum, 1934), certainly argues for this interpretation.

In this respect, the status of dopaoxidase is still in doubt. Since the original description of this enzyme in rat tumors (Bloch, 1917), there have been occasional reports of its occurrence elsewhere, as, for example, in insects (Hasebrock, 1921), and in mammalian tumors and ciliary bodies (Hogeboom and Adams, 1942; Herrmann and Boss, 1945). However, the specificity attributed to dopaoxidase has been called in question by Franke (1934), who has contended that the ease with which dopa is known to oxidize suggests that the reaction is non-catalytic. Moreover, Figge (1941) has suggested that dopaoxidase may be only a part of the tyrosinase complex, since it is possible that its monophenolase activity is inhibited by the low oxidation-reduction potentials of normal tissues. Another reason for the suppression of the monophenolase activity of tyrosinase is supplied by the work of Behm and Nelson (1944), who found that tyrosinase must first oxidize an ortho-diphenol before it can attack monophenols. Consequently, it is possible that the reported specificity of dopaoxidase depends only upon the fact that ortho-diphenols were absent when the enzyme's effect on monophenols was tested. That this applies to melanoma extracts, at least, has been shown by Lerner, Fitzpatrick, Calkins, and Summerson (1949), for they were able to show that catalytic amounts of dopa promote the oxidation of tyrosine. Further evidence in support of this view has been furnished by Sizer and Brindley (1949), who have shown that 10^{-4} M catechol accelerates and makes more extensive the action of tyrosinase on the tyrosyl groups of certain proteins. Finally, Blaschko and Jacobson (1942) have shown that dopa is oxidized by cytochrome oxidase when cytochrome C is present. Since the latter enzyme is so widely distributed, one wonders whether any significance can be attached to the demonstration of the presence of a dopaoxidase unless adequate precautions have been taken to exclude the action of the cytochromes. For these reasons, then, it is probable that dopaoxidase should be considered a part of the tyrosinase complex, and, as such, not a separate enzyme.

However, it cannot be doubted that copper protein oxidases, other than tyrosinase, do exist in insects. For example, small quantities of laccase were found to coexist with tyrosinase in certain of the Lepidoptera investigated by Pugh (1934). Moreover, Bodine and his associates (Bodine et al., 1939, 1940, 1944, 1949) have demonstrated the presence of an enzyme which they have called protyrosinase in extracts of grasshopper eggs and of larvae of *Tenebrio molitor*. This enzyme they considered to be an inactive form of tyrosinase which can be activated by the use of protein denaturants like chloroform, methyl alcohol, heavy metals, or detergents.

The evidence, then, seems to suggest that, while tyrosinase is almost universally present among insects, other copper oxidases occur only sporadically. Although tyrosinase is probably a single enzyme complex, its action can be modified by certain other enzyme systems whose interrelationships with tyrosinase will be discussed in a subsequent section.

THE DISTRIBUTION OF TYROSINASE IN INSECTS

The location of tyrosinase within the animal has been investigated, and it has been found that this enzyme probably occurs in both the hemolymph and the hemocytes. For example, Teodoro (1931) found it to be present in the hemolymph of *Bombyx* (Hymenoptera), while certain of the Lepidoptera (Brecher, 1934) and Diptera (Dennell, 1947) were shown to contain the enzyme within their hemocytes. Because of the open nature of the circulation of insects, it is probable that the enzyme is widely distributed throughout the other tissues of the animal. Evidence in support of this has been offered by Biedermann (1898) and by Brecher (1934), who discovered the enzyme to be present in the gut and the tracheal matrix of caterpillars and pupae. Furthermore, Tower (1906), Henke (1924),

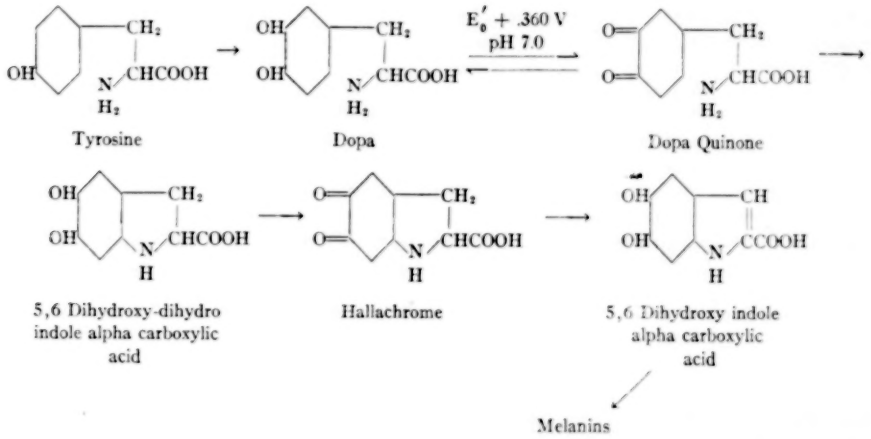
Bhagvat and Richter (1938), and Dennell (1947) have shown that tyrosinase occurs in the integument of many insects, while Becker (1937) has demonstrated its presence in the fat body and pericardial cells of vespids. A rather special case, in which the enzyme has been shown to be localized within a gland-like organ, is that described by Pryor (1940), who found that certain of the Orthoptera use the enzyme in the construction of their oothecae.

Although tyrosinase is widely distributed among the insects, the amount present at any one time depends upon the state of development of the animal (Phisalix, 1905; Roques, 1909; Brecher, 1934), upon the sex of the animal (Yamafuji, 1934), and upon various genetic factors (Graubard, 1933). These variations in the quantity of the enzyme have led to certain theories which have attempted to explain metamorphosis in insects (see section below on functions).

SUBSTRATES UTILIZED BY TYROSINASE IN VIVO

Many substrates can function as chromogens for tyrosinase in vitro, but very few have been shown actually to do so in the living insect. Tyrosine has been found to function in the coloring of the integument of the Diptera (Gessard, 1904; Fraenkel and Rudall, 1947) and in the blackening of the blood and cuticle of the Lepidoptera (Dembowski and Brecher, 1921). This compound is generally thought to be the precursor of most melanic pigments produced by insects (Wigglesworth, 1947). However, 3,4-dihydroxyphenylalanine (dopa) has been found to occur in the wing covers of *Meloiontha* (Coleoptera) (Schmalfuss and Müller, 1927), in cocoons of certain saturniids (Lepidoptera) (Przibram and Schmalfuss, 1927), and in the blood of *Calliphora* (Diptera) (Pryor, 1940). Because of the rapidity of oxidation of dopa to colored substances, it has been suggested that it is the chromogen active in the coloring of the above animals. A compound closely related to dopa, namely 3,4-dihydroxyphenyl acetic acid, has been found to be present in certain plants and animals wherein it is also thought to function in pigmentation (Schmalfuss, Heider, and Winkelmann, 1933), and the above compound and dihydroxyphenyl lactic acid have been found to be concerned in the hardening of the cuticle of *Tenebrio* (Pryor, Russell and Todd, 1947). Furthermore, it is probable, as the latter authors suggested, that compounds like dihydroxyphenyl lactic acid and dihydroxyphenyl acetic acid arise as stable degradation products of dopa. Finally, it has also been shown that protocatechuic acid functions with tyrosinase and a protein to form the ootheca of cockroaches (Pryor, Russell, and Todd, 1946).

However, despite the presence of other compounds like dopa and protocatechuic acid in insects, it seems fairly well established that tyrosine is the principal precursor of melanins in these animals. The reason for this is suggested by the following formulation of the action of tyrosinase in the formation of melanins (modified from Elvehjem and Wilson, 1940; Figge, 1940):



It can be seen from the above scheme that tyrosine would be expected to be the ultimate precursor of melanins, and that dopa and 3,4-dihydroxyphenyl acetic acid probably arise as oxidation products of tyrosine. Recently, Mason (1948) has shown that the red pigment which is produced upon the oxidation of dopa quinone differs from hallachrome spectrofluorometrically, but that the substance involved is ortho-quinonoid in nature, as was inferred by Raper (1927). Though Figge (1940) has suggested that melanin is a physiological redox indicator, this seems improbable as melanin is a highly insoluble polymer. However, there is some reason to believe that dopa and dopa quinone and hallachrome and leucohallachrome constitute reversible systems, so that under certain conditions there is the possibility that precursors of melanin may function as redox indicators. That pH can also influence the products of the tyrosinase reaction has been suggested by Mason and Wright (1949), who claim that in alkaline solutions melanin is formed but in acid solutions hallachrome is reduced to leucohallachrome.

According to Raper and Wormall's (1923) original suggestion, the stages beyond the formation of dopa occur non-enzymatically. This has been fairly generally accepted as true, except that Danneel (1943) has claimed to have demonstrated the presence of an enzyme which catalyses the oxidation of hallachrome in ground pupae of *Drosophila melanogaster* (Diptera). This enzyme was found to be destroyed by heating at 60°C for a short time, but is not sensitive to cyanide. According to Danneel, this enzyme is not found in the melanophores of rabbit skin and has not been found to occur in any other animal, so that further information is required before its significance can be properly evaluated.

It has also been suggested that tyrosine or one of its subsequent products is deaminated before it is linked with cuticle proteins in the tanning of the insect integument (Pryor, 1940a, b). More recently, Pryor, Russell, and Todd (1947) and Fraenkel and Rudall (1947) have shown that degradation products of dopa, such as dihydroxyphenyl lactic acid and dyhydroxyphenyl acetic acid, play an important role in the formation of the cuticle. Therefore, it is probable that the above scheme for the formation of melanins by the action of tyrosinase will have to be modified before it can explain certain of the functions of the enzyme, such as the formation of the insect cuticle.

INTERRELATIONSHIPS OF TYROSINASE AND OTHER ENZYME SYSTEMS

Thus far we have considered the tyrosinase system as one isolated from the other systems of the insect. However, in order to understand the functioning of tyrosinase in the animal, it is necessary to consider it in relation to those other systems which may modify and, in some cases, control the action of the oxidase in vivo.

Redox potentials and tyrosinase

It may be asked why it is that the normal animal doesn't blacken despite the simultaneous presence of chromogen, oxygen, and enzyme in it. An analogous case, in potatoes, was explained by Szent-Györgyi and Victorisz (1931) by the suggestion that no blackening results in the undamaged tissues because the quinone formed by the oxidation of phenols is rapidly reduced. It has been claimed by Dennell (1947), who investigated the relationship of redox potentials to darkening and hardening of the integument of *Sarcophaga* (Diptera) that the aerobic E_h of the larva is in the neighborhood of + .120 volts, as estimated by dyes, and he concluded from this that tyrosinase activity in mature larvae is prevented by the low oxidation-reduction potential of the blood. In a later paper Dennell has suggested (1949) that dehydrogenase activity was responsible for the maintenance of the potentials noted in the experiments above. He measured dehydrogenase activity in terms of the oxygen uptake of cyanide-poisoned tissues. It must be noted, however, that the cyanide-insensitive respiration measured in this way will provide data only about the aerobic dehydrogenases. Moreover, much more definitive work will have to be done on the characterization of the "glucose dehydrogenase" worked on by Dennell before it can be claimed that this is the factor responsible for the maintenance of the redox potential in insect blood. There is confusion in the work of Dennell and others in the matter of the accumulation of phenols and their products, and the activity of the enzyme tyrosinase. The presence of reducing substances may prevent the accumulation of the products of tyrosinase activity without inhibition of the enzymatic oxidation. However, it is possible that tyrosinase inhibitors may occur and these may be

reducing substances, but this may only be demonstrated by following the oxidation of phenolic substrates of tyrosinase by measuring the oxygen uptake.

It has been suggested that other enzyme systems are influenced by variations in the oxidation-reduction potential. For example, Reiss (1943, 1944) and Reiss and Achard (1944, 1946) measured the changes in potential during the development of about nine species of the Lepidoptera and concluded that changes in redox potential probably regulate the lytic and synthetic activity of proteinases and other enzymes involved in tissue reconstruction. Moreover, in other organisms, it has been found that proteolysis of tumor tissues was inhibited by oxidants and reactivated by reductants (Krebs, 1931; Rondoni and Pozzi, 1933). Sawano (1935) was able to activate cathepsin from a protozoan by the use of glutathione and cysteine, while Sumner and Poland (1933) and Sizer and Tytell (1941) were able to demonstrate the importance of a reducing agent in the activation of urease. Furthermore, plant and pancreatic amylases (Pringsheim, Borchardt, and Hupfer, 1931), glyoxylase (Jowett and Quastel, 1933), phosphatase (Roche and Martin-Poggi, 1941), certain hemolysins (Shwachman, Hellerman, and Cohen, 1934), and still other enzymes (Reiss, 1943) were also activated by glutathione. It is probable that in the majority of these cases one is dealing with an enzyme which is active when its sulfhydryl groups are free but inactive when these are oxidized to the S—S condition. Therefore, the activity of the enzyme is determined by the amount of enzyme present in the —SH form. Under different environmental conditions, then, the enzyme may be active or inactive, depending upon the availability of —SH compounds in the tissues.

Whereas the previous work has suggested that an enzyme may be inhibited in the presence of a strongly positive or strongly negative system, another possibility has been suggested by the work of Figge (1940). This investigator observed that in the amphibian *Amblystoma* phenol indophenol inhibits melanin production in melanophores, but accelerates the pigmentation of connective tissue. Figge interpreted this as being due to the fact that tyrosinase is most active in some intermediate range of redox potential (E_0' + .00 to + .01). Therefore, upon the introduction of a redox dye with a highly positive potential, the potential of the melanophore is shifted away from the optimum for melanization, while that of the connective tissue is brought up to the optimum for pigmentation to occur. Consequently, coloring of the melanophore is inhibited at the same time that coloring of the connective tissue is accelerated. In order to account for the maintenance of a potential near the optimum, Figge proposed that two of the intermediate products of the reaction, hallachrome and leuco-hallachrome (5,6-dihydroxydihydroindole alpha carboxylic acid) serve to form a redox system (E_0' + .022v at pH 7.0) which suppresses the dopa system.

However, Figge's interpretations are open to serious question, since his methods of measuring oxidation-reduction potentials by visual observations of dyes could lead to serious error even if equilibrium conditions existed. In the absence of equilibrium conditions, color is determined only by the relative rates of oxidation and reduction and is no measure of the potential at all. Secondly, though it is well recognized that the activity of many enzymes depends upon their being sulfhydryl enzymes, there is no evidence that activity of any single enzyme is determined by the oxidation-reduction potential of its environment, per se. Further, the whole question of what constitutes an oxidation-reduction potential in living systems is open to question, even though apparent potentials may readily be observed with a metal electrode in a suspension of cells. An oxidation-reduction potential is defined as an equilibrium potential (Umbreit, Burris, and Stauffer, 1945; Hewitt, 1948), whereas the concentration of a particular oxidant or reductant in a cell is determined by the relative rates of its formation and removal. Even though one may readily observe a potential, as in the experiments of Reiss and co-workers cited above, an oxidation-reduction potential cannot be measured by merely placing one electrode inside an animal and one outside on the surface of its integument.

The effect of tyrosinase on intact proteins

Another approach to the analysis of the interrelationship of tyrosinase to other enzymes is furnished by the work of Sizer (1946, 1947), who has found that tyrosinase has the ability to oxidize certain of the tyrosyl groups of intact proteins. That biologically active materials are susceptible to the oxidative action of tyrosinase is demonstrated by the fact that tyrosyl groups of proteins like chymotrypsin, insulin, pepsin, and trypsin are

oxidized by the enzyme. In these experiments, Sizer was not able to demonstrate that the oxidation of the tyrosyl groups affects the action of the enzyme. More recently, however, he showed (Sizer, 1948) that invertase can be inactivated by tyrosinase, and that pepsin activity can also be affected by this treatment (Sizer and Brindley, 1949). These experiments would seem to confirm the observations of Groxatto and de la Maza (1945), who have claimed that tyrosinase (from *Psalliota campestris*) can destroy the pressor action of pitressin and adrenalin. Since the tyrosyl group is necessary for the activity of most biologically active proteins (Olcott and Fraenkel-Conrat, 1947), the effect of tyrosinase upon that group may prove to be of considerable significance in the control or modification of the action of enzyme systems like the dehydrogenases, etc. It must be remembered, however, that some of these experiments have been criticized by Edman (1947), who has claimed that Sizer's results could be explained by the action of tyrosinase upon products of protein autolysis, rather than upon the intact molecule. Although Sizer (1947) has shown that the removal of these products by continual dialysis during the course of the reaction does not significantly affect the oxidation of the residual protein, it is likely that further evidence will have to be provided before the real significance of these observations can be assessed.

FUNCTIONS OF TYROSINASE IN THE INSECT

Pigment formation

Before the enzymic nature of the formation of melanins was established, it was thought that the physical environment was wholly responsible for determining the coloring of insects. Poulton (1892), Tower (1906), and others attempted to show that pigment formation in insects depends upon such factors as the color of background, type of soil in which they are reared, amount of light, etc. (see review by Dewitz, 1921). Similarly, the many observations of melanic races of butterflies in industrial areas argued for such an interpretation (Huxley, 1942). However, with the discovery of tyrosinase and the elucidation of its role in pigmentation, it could be shown that the environment affects only the conditions under which the enzyme can operate most effectively. For example, Dewitz (1902, 1916, 1921) showed that the color of the cocoons of Lepidoptera depends on the amount of moisture which is available during the time of spinning. These experiments were preceded by those of v. Fürth and Schneider (1901) who proved by preventing the coloration of its blood after dehydration over H_2SO_4 that moisture is necessary for the pigmentation of pupae in vitro. Therefore, in damp weather, dark cocoons are formed, while the reverse is true for dry weather. By demonstrating this, v. Fürth and Schneider were able to prove that other environmental factors, like light, had no effect upon the color of the cocoon, as Poulton (1892) and others had previously suggested. On the other hand, under artificial conditions of illumination light of certain wave-lengths has been shown to affect the pigmentation of *Pieris* (Lepidoptera) (Brecher, 1921) and *Ephestia* (Lepidoptera) (Schmalfuss, Schmalfuss, and Bussman, 1937), while Pincussen and Hammerich (1931) have demonstrated that tyrosinase is inhibited by ultraviolet radiation in vitro. However, it seems probable that, in nature, light alone has little effect upon pigmentation, since the intensity of such radiation is too low to affect the enzyme.

In contrast to light, temperature has been found to play an important part in melanin formation in nature. However, this effect upon pigmentation in the insect seems to depend not upon its effect upon the enzyme system itself, but rather upon its effect upon the animal's body as a whole ("Gesamtzustand" of Henke, 1924; Tenenbaum, 1934). Henke showed that coloring of the elytra and epimera of *Pyrrhocoris* (Coleoptera) is accentuated with small rises in temperature, while abundant moisture increases this effect. However, spot sizes on the neck plate (Halsschild) were found to be reduced in size with small rises in temperature, so that it must be concluded that individual regions of this insect's body responded differently to small increases in temperature. It was also found by Henke that large increments in temperature increase the amount of pigmentation all over the animal's body. This work has been extended by Schlottke (1926), who found that the reaction of *Habrobracon* (Hymenoptera) to temperature stimuli depends upon the stage of development at the time of exposure, as well as the magnitude and duration of the temperature changes. He also noted that animals kept in moderate cold blacken more than do organisms kept at warmer temperatures. In contrast to these results, Schmalfuss, Schmalfuss, and Bussman (1937) found that exposure to cold (0°C) for more than a day inhibits the pigmentation of *Ephestia*, although exposures for only one day have little effect.

Other observations have appeared in the literature concerning the effect of cold and warm temperatures upon pigmentation (cf. Dewitz, 1921; Henke, 1924; Giersburg, 1929) but, in general, the effect of temperature upon pigmentation would seem to depend upon the physiological condition of the individual tissue involved.

Pigment patterns

In the formation of the pigment patterns of insect wings, elytra, etc., the most important variable factor seems to be the chromogen content of the area undergoing coloration. Numerous investigators have shown that the enzyme is probably distributed throughout the tissues of the animal while pigmentation is occurring, yet patterns are still produced (Gortner, 1910, 1911a, b; Hasebrock, 1921; Henke, 1924; Tenenbaum, 1934; Dennell, 1947). It has been shown, for example, that the region where spots appear in coccinelids is where the chromogen is produced (Tenenbaum, 1934), and the same has been found to be true for the pigmentation of the wings of certain of the Lepidoptera (Braun, 1939). In experiments with higher animals, Bloch (1917) showed that pigmentation of mouse tumors depends upon the quantity of chromogen available, and not upon the amount of oxidase.

Another factor which has been shown to influence the localization of pigment production is the oxidation-reduction potential of the system (Dennell, 1947), as in the coloring and hardening of the integument of *Sarcophaga* larvae. Figge (1940) reported that differences in the pigmentation of melanophores and connective tissue of an amphibian depend upon the redox potential (see section on redox potentials and tyrosinase). It should also be noted that Köhler (1932) suggested that wing patterns in *Ephestia* could be explained by differences in the metabolic intensity (Stoffwechselintensität) of various parts of the wing, but he was not able to measure this factor. Williams (1942) has disproved this by setting up temperature gradients in the wings of *Samia* (Lepidoptera) and showing that warmer portions of the wings acquire color before the cooler ones have even begun to do so. If differences in metabolic intensity were responsible for pattern formation, then it would be expected that the imposed temperature gradient would produce a pattern different from that of the normal animals. However, this did not prove to be the case. After pigmentation had occurred, the patterns were identical in both the treated and untreated animals. Therefore, it is likely that the formation of patterns of melanic pigments is governed by a complex of factors involving the localization of chomogen and the physiological state of the tissue, factors which are, in turn, influenced by the presence of hormones and the state of the insect's development.

Formation of cuticle

Another function of tyrosinase which has been investigated is its relation to the pigmentation and hardening of the insect integument (see review by Wigglesworth, 1948). The connection between the pigmentation and the hardening of the cuticle has long been recognized, for it was often observed that the same agents which hinder the coloring of cocoons and integuments, etc., also hinder the hardening of these structures (Dewitz, 1916; Phisalix, 1905; Biedermann, 1914; Brecher, 1921; Henke, 1924). Then Campbell (1929) was able to demonstrate that the extent of chitinization of the cuticle of *Periplaneta* (Blattaria) has no relation to its hardness. In contrast, Schultze (1922) and Kühnelt (1928) had suggested that encrusting substances were responsible for the hardening, and Becker (1937) even afterwards insisted that coloring and hardening are independent processes. Meanwhile Schmalfuss, Schmalfuss, and Bussman (1937) showed that the hardness of the cuticle of *Ephestia* is proportional to the content of chromogen. Moreover, they measured the amount of weight that can be supported by the wings at various stages of development and found that the fully colored ones can support more than a thousand times as much weight as the uncolored ones. It remained for Pryor (1940a, b) to demonstrate what sort of mechanism is active in the simultaneous hardening and pigmentation of cuticles and oothecae. He showed that the cockroach ootheca and the integument of *Calliphora* larva are composed of a protein which is hardened by a tanning process that involves the oxidation of phenolic compounds that are derived from the blood. Finally, Dennell (1947) was able to show that tyrosinase, by oxidizing the tyrosine in the blood, is responsible for the production of the quinones which harden the puparia of *Sarcophaga*, therefore confirming the observations of Trim (1941). Fraenkel and Rudall (1947) extended these observations and calculated that the gain in weight of the pupal cuticle over that of the larval cuticle corresponds to the decrease of free tyrosine in the

blood. These investigators also described the properties and composition of the protein of the insect cuticle, and discussed the production of the quinones derived from tyrosine which combine with the cuticle substance. It is entirely likely, as Dennell points out, that the process described for the formation of the cuticle in the *Diptera* is of importance in the other orders of insects, as well as in related arthropods.

Metamorphosis and tyrosinase

That tyrosinase is of importance in metamorphosis was first suggested by the observations that the amount of tyrosinase present in the animal varies with the stage of development (Gessard, 1904; Roques, 1909; Dewitz, 1916; Schlottke, 1926; Graubard, 1933; Brecher, 1934; Yamafuji, 1934). In general, the egg and the very young larva were shown to be devoid of tyrosinase, while the older larvae show increasing amounts until pupation, whereupon a rapid decrease in the amount of enzyme becomes apparent. Giard (1900) discussed theories connecting the darkening of insect blood with metamorphosis, but it remained for Dewitz (1902, 1916) to suggest that tyrosinase itself is responsible for metamorphosis.

This extreme view was refuted by the demonstration of the existence of a puparium-evoking hormone in *Calliphora* by Fraenkel (1935) and by the subsequent work of others (Burtt, 1937, 1938; and others). It seems, then, that in order to understand fully the relation of tyrosinase to metamorphosis, the enzyme's relation to the puparium-evoking hormone must be investigated. Such an investigation was performed by Dennell (1947), who showed by experiments using ligatures that the hormone-induced changes in the oxidation-reduction potential of the blood can be correlated with the activity of tyrosinase in producing blackening upon pupation (see section on pigmentation). Dennell concluded that the hormone acts by destroying the reducing power of dehydrogenases to the point where the oxidation products of tyrosinase can accumulate. The relation between the reducing power of the blood and its glucose content has been investigated (Kuwana, 1937; Heller and Moklowska, 1930; Hemmingsen, 1924), but it is not likely that either this substance or uric acid (Dennell, 1947) can be responsible for the inhibition of tyrosinase in vivo. The exact nature of the hormone which evokes puparium formation has never been elucidated, but Becker and Plagge (1939) found it to be soluble in water, alcohol, butyl alcohol, and ethyl acetate, but not in lipid solvents. In this connection, it is of interest to note that Rothman, Krysa, and Smilvanic (1946) observed that aqueous extracts of human epidermis inhibit the oxidation of tyrosine and dopa. It was later shown (Flesch and Rothman, 1948) that this effect is counteracted by iodoacetamide, chloromercuric ions, or cupric ions, so that it could be concluded that sulfhydryl groups are responsible for this inhibition. It is possible that –SH groups will be found similarly inhibitory for tyrosinase in insects, and that the puparium-evoking hormone acts to bind these groups. It would seem that what is needed here is experimental proof to show whether the sulfhydryl compound acts on the products of the reaction or upon the enzyme itself. Moreover, a continuous supply of the hormone would not have to be postulated for such a mechanism to operate, since the quinones produced by the oxidation of phenol could serve to bind the sulfhydryl groups of dehydrogenases (Bergstermann and Stein, 1944), and so induce a kind of autocatalysis. Since tyrosinase has been found not to depend on free –SH groups for its action (Elliott, 1946), such an effect would not hinder the action of the oxidase.

Injury and tyrosinase

Although the effect of tyrosinase upon intact protein has been investigated only recently, the effect of the enzyme upon autolyzed proteins and their products has long been recognized. For example, the action in vitro of fungous tyrosinase upon polypeptides and other products of protein breakdown was investigated by several workers (Harlay, 1900; Chodat and Staub, 1907; Abderhalden and Guggenheim, 1907). The effect in vivo of tyrosinase upon the products of protein degeneration was investigated by v. Fürth and Schneider (1901), who stated that the chromogen for pigment production by tyrosinase in animals was formed by autolyzing proteins. Then Linden (1904) attempted to correlate the destruction of protein, as a result of freezing and of heating, with the blackening of the insect; and a similar correlation was made by Schultz (1915) for pigment formation in grafts upon warm-blooded animals.

The fact that the oxidase could act upon the phenolic products of protein breakdown suggested a function that the enzyme could serve in the animal, namely, that of removal of the toxic

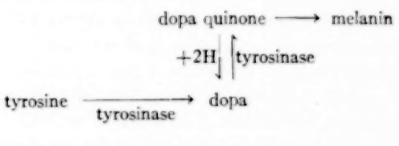
products of such protein degeneration. As a consequence, Henke (1924) and Cordier (1928) proposed that pigment formation serves to remove toxic products liberated upon injury to the insect. A similar suggestion was made for the tyrosinase of other organisms, such as *Cancer*, the crab (Bhagvat and Richter, 1938; Pinhey, 1930). There is very little experimental evidence to support this idea, but the data of Schlottke (1926) are of interest, since he found that the point at which *Habrobracon* is least sensitive to drastic changes in temperature is the very point at which pigmentation occurs. Therefore, if it were assumed that such changes in temperature cause an autolysis of proteins, with subsequent liberation of phenols, then it follows that pigmentation, in this case, might have served to remove these toxic substances and by this means to prevent the poisoning of the animal. In this connection, certain observations of the present author (unpublished) in work with a disease of diapausing pupae of *Platysamia cecropia* (Lepidoptera) are of interest. I have found that trauma, due to the excision of parts of the integument and underlying epithelium, induces a temporary rise in the apparent redox potential of the blood, a rise which can be correlated with the deposit of melanin granules. This suggests that the phenols which accumulated at the time of injury are removed from the blood by the tyrosinase and deposited in the form of insoluble melanins. However, no quantitative comparison of the amount of free phenols present in the blood before and after injury has ever been correlated with the action of tyrosinase in the removal of these compounds. It must be concluded that most of the evidence that connects tyrosinase with detoxification mechanisms in the animal is inferential, and more direct proof will be required before the question can be settled.

That tyrosinase functions to increase the respiration of injured tissues has been suggested by Szent-Györgyi and Victorisz (1931). These workers found the oxygen uptake of damaged potatoes to be increased 15-fold, due to the oxidation of phenols. [The phenol involved in potatoes was later identified as tyrosine by Schmalfuss and Bumbacher (1943) and by Robinson and Nelson (1944).] Yet there is little direct evidence from work on insects to support this theory, except for my own investigations on the respiration of intact and ground-up pupae of *Platysamia*. This work has shown that phenols increase the oxygen uptake of "brei"s, although tyrosinase seems to play no part in normal respiration. However, it is not yet possible to state that this increase in oxygen uptake is concerned with energy-yielding processes of the insect body, so that its real significance to the animal is still in doubt.

Tyrosinase and respiration

The localization of melanic pigments and tyrosinase at the sites of the greatest metabolic intensity in insects has led to the idea that this enzyme is actively involved in the metabolic processes of the animal. For example, Tower (1906), Génieys (1922), and Becker (1937) showed that tyrosinase occurs in integuments over the muscle insertions or directly in the muscles, as well as the fat body and pericardial cells of vespids (Becker, 1937). In fact, Graupner (1934) showed that melanic pigments occur only in the neighborhood of tissues with high metabolic intensity, while Köhler (1932) insisted that metabolic intensity (Stoffwechselsintensität) determines where melanization will occur. Heller (1947) attempted to correlate this data with the respiration of pupae of *Celerio* (Lepidoptera) by postulating that the tyrosinase-tyrosine system functions as a terminal oxidase in the normal animal. This investigator worked with "brei"s and found that addition of a cozymase preparation produces a prolonged rise in respiratory activity. Moreover, the addition of 1/20,000 M KCN was found to augment the oxygen uptake of the "brei," the increase being due to the inhibition of catalase.

A mechanism whereby tyrosinase functions as a terminal oxidase has been demonstrated to occur in plants (Baker and Nelson, 1943; Boswell, 1945; Walter and Nelson, 1945; Bonner and Wildman, 1946). The following scheme was suggested:



Recently, however, some of these results have been called in question. Levy, Schade, Bergmann, and Harris (1948) have reinvestigated the respiration of the white potato and have concluded that tyrosinase does not function as the terminal oxidase in this system. They claim to have demonstrated the presence of a cytochrome system that functions in

oxygen transport. This recalls the work of Szent-Györgyi and Victorisz (1931) who also claimed that tyrosinase does not function in the normal respiration of the potato, but serves so only upon injury. Despite the wide acceptance of the respiratory role of tyrosinase in plants, further work may be necessary in order to establish this definitely.

Not nearly as much work has been done upon the respiratory role of tyrosinase in insects. Heller's (1947) work, which was reviewed above, seems to have been the only attempt to establish such a function for the enzyme experimentally. However, his interpretation of the data is subject to some criticism since he has not satisfactorily explained why KCN should serve to increase the respiration of the "brei," inasmuch as tyrosinase, as well as catalase, is cyanide sensitive. Furthermore, the production of a tissue homogenate may introduce factors which alter the balance of enzyme systems (Elliott, 1946) and make extrapolation from the situation in a "brei" to that in the normal animal misleading. In order to check these points and to compare the role of tyrosinase in vivo with its role in vitro, the present author has performed a number of experiments to investigate the respiratory mechanisms of diapausing pupae of *Platysamia cecropia*. In these experiments it was found that the addition of copper protein poisons or phenolic substrates for the enzyme had no effect on the respiration of the animal in vivo. On the other hand, these compounds had a marked effect on the respiration of "brei"s. It was concluded from this that tyrosinase is probably not involved in the normal respiration of the pupa, but seems to function only when the tissues of the animal are destroyed.

SUMMARY

The attempt to ascribe a fundamental role to tyrosinase in the control of insect metamorphosis is not supported by the facts to date. It would seem more likely that the enzyme operates only as a result of certain changes evoked by hormones, etc., rather than by initiating these changes itself. If this be so, the primary role played by tyrosinase during metamorphosis is a structural one, wherein the enzyme aids in the formation of the cuticle and in the deposition of the melanic pigments.

Whereas these structural functions explain the function of tyrosinase during metamorphosis, the relation of the enzyme to other physiologic activities of the insect is more obscure. For example, it has been suggested that tyrosinase functions as a terminal oxidase in the respiration of intact animals, but recent work has tended to disprove this. The possibility does exist that the oxidase serves to increase the respiration of damaged tissues, by increasing their rate of oxygen uptake. Another function that tyrosinase may perform in the injured animal is that of detoxification, by removing the phenols which accumulate due to the breakdown of proteins.

In the final analysis, it is plain that we can not consider tyrosinase separately from the organism as a whole. It is an intimate part of the entire complex of enzyme systems represented in the insect body, and influences and is influenced by these other systems. It is probable that only through the investigation of such relationships will the true role of tyrosinase in the organism be elucidated.

This review comprises a portion of a thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Harvard University.

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NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Associate Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

BEETLES AND CONTINENTS

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A review of LA GENÈSE DES FAUNES TERRESTRES: *Éléments de Biogéographie.*

By René Jeannel. Presses Universitaires de France, Paris. 250fr. viii + 513 pp., 213 figs., 8 pls. 1942.

René Jeannel is a distinguished entomologist, now Professor at the Muséum National d'Histoire Naturelle at Paris, and one of the most productive taxonomists of his time. His thousands of pages of work on the Carabidae and other beetles have been notable for a broad point of view, readiness to abandon old classifications and set up new ones, utilization of new characters drawn especially from the male genitalia, and copious illustration. He is also a professed Lamarckian and Wegenerian. It is necessary to know at least this much about the author of *La Genèse des Faunes Terrestres* to understand the book, for it is a peculiarly personal one. It is also an important one because of the influence it is likely to have on uncritical readers, and because later works by the same author, presumably marked by the same point of view and the same methods, are coming to the attention of American biologists (see reviews in the *Quart. Rev. Biol.*, 23: 233–234, 250–251. 1948). The book was published in Occupied France during the war and was delayed in reaching this country. I shall review it here at some length for these reasons, and because I have nearly the same professional interests as the author, including both biogeography and carabid taxonomy and distribution.

The first part of the book concerns evolution. Various kinds of isolation and segregation are discussed in so far as they affect the formation of species. Many of the examples given are new. What Jeannel has to say about genital isolation in insects (pp. 12–16) is authoritative. He rejects the old "lock and key" theory, which proposed that mating between closely related insect populations is prevented simply by failure of the male's copulatory organs to fit the female's, and concludes that genital differences are usually a result, and not the cause, of isolation. He thinks that the isolation effective in the formation of new species is usually geographical or ecological, or perhaps physiological. He is probably right about this, although cases do occur in which interspecific mating may be mechanically difficult. Valentine (*J. Elisha Mitchell Soc.*, 51: 341–342. 1935) has published interesting comments on this, with other examples from the Carabidae. Jeannel's further discussion of evolution and adaptation is colored not only by his Lamarckianism but by a belief in various sorts of orthogenesis which seem at best to be oversimplifications.

The second part of the book covers briefly the general principles of animal distribution and ecology. It is notable for certain fresh examples of old principles and for a discussion of subterranean faunas (pp. 88–96), to the knowledge of which Jeannel himself has made substantial contributions.

The third part of the book is on paleogeography. It includes an account of, and acceptance of Wegener's hypothesis of continental drift, as modified by Du Toit and others. The eight plates at the end of the book illustrate the evolution of the continents according to this hypothesis.

The last part of the book, actually three-fourths of the whole, is concerned with the geographical origins of insect faunas. The various ancient, hypothetical combinations of continents postulated by Wegenerians are considered one by one, and an attempt is made to fit to them the distributions of existing insect groups. When an apparent fit is found, the insects are said to have originated on or spread from the Wegenerian area in question. For example, if a group of insects now occurs only or chiefly in Africa and South America, it is said to have originated on or spread from a hypothetical Africano-Brazilian continent. By this sort of

superficial matching the following hypothetical history is worked out.

Existing insects have come from three ancient land masses: Laurentia (roughly equivalent to North America with Europe attached), Angara (Asia without Europe or India), and Gondwana (South America, Africa, India, Australia, and the Antarctic, all in one great southern land mass). (Laurentia and Angara were parts of a still earlier great northern land mass, Laurasia.)

Laurentia has contributed only a little to existing faunas. It lost most of its original insects even before the Mesozoic. Gondwana was the principal place of evolution of insects during the Triassic and Jurassic. During this time Gondwana divided into two parts, called by Jeannel Paleantarctica ("*La Paléantarctide*," combining the southern part of South America, Australia, present Antarctica, and various islands including New Zealand) and Inabresia ("*L'Inabrésie*," from *INde, Afrique, BRÉSil*, combining the main parts of South America, Africa, Madagascar, India, and the Malay region). Later, Paleantarctica broke into its present separate parts, some of its insects surviving as existing South America-New Zealand-Australian groups. Inabresia also broke up, forming first two main parts. On the eastern part evolved the "*gondwaniennes orientales*" lines of insects now common to Africa, Madagascar, and the Orient. On the western part evolved the "*africano-brésiliennes*" lines of insects now common to Africa and South America. Later, of course, both parts of Gondwana broke up further and some of the fragments recombined in new ways (e.g., a western piece of Inabresia joined a piece of Paleantarctica to form South America, and India became joined to Asia), and each fragment carried appropriate insects. Some of the latter eventually reached North America, Asia, and other parts of the world by Wegenerian routes.

Angara (Asia) was populated from eastern Gondwana chiefly during the Mesozoic, and during the Cretaceous it became a great secondary center of insect evolution, from which many groups have spread through the northern hemisphere. Europe became joined to Angara, and received most of its existing insects from the latter by complex invasions during the Tertiary, and some of the insects reached North America from Europe by a North Atlantic connection early in the Tertiary.

North America, according to this hypothetical history, now has an insect fauna that consists of (1) a few pre-Jurassic relicts of Laurentian groups, (2) Africano-Brazilian Gondwanan groups which reached North America from the south about the beginning of the Tertiary, (3) eastern Gondwanan stocks which radiated in Asia and reached North America across the Bering region about the beginning of the Tertiary, (4) additional stocks from the same source which reached North America from Europe by a North Atlantic connection early in the Tertiary, and (5) additional Africano-Brazilian stocks which came from South America via Central America in the Pliocene. A very large number of details has been omitted in this summary.

Many of the details of this history are obviously right, at least as regards the Tertiary. We have a good knowledge of the movements of terrestrial faunas during this period, based on an extensive fossil record, especially of the mammals, and Jeannel has quite properly fitted his history of Tertiary insect distribution to this record. It should be noted, however, that Simpson's latest analysis of northern Tertiary mammal faunas (*Bull. Geol. Soc. Amer.*, 58: 613–688. 1947) throws doubt on the supposed North Atlantic land connection. Jeannel's account of the populating of the mountains of Europe (pp. 463–478) and of Africa (pp. 330–337) by carabids during the Tertiary is a valuable and original contribution.

That many groups of insects arose in the Old World tropics (nearly equivalent to eastern Gondwana), perhaps before the Tertiary, invaded Asia and radiated there, and then spread through the whole north temperate zone is a good working hypothesis—but not necessarily Wegenerian. In fact, it is a good working hypothesis that successive insect faunas have always tended to evolve in the tropics, especially in those of the Old World, and then in part to spread into and undergo secondary evolution in both north and south temperate zones. In some ways, such a history would not be very different from that set forth in *La Genèse des Faunes Terrestres*, except that it need not be Wegenerian. The best that can be said of the Wegenerian details of the book is that they are unnecessary—or so it seems to me.

Several usually unstated assumptions underlie this book and other Wegenerian zoogeography in which the method is to match distributions of existing animals against patterns of hypothetical ancient lands. First, it is assumed that animal distributions are more permanent than land; in the present case, that insects have moved less than continents. The whole method depends on this. A necessary corollary is that faunas are inherently stable, gradually spread, but rarely recede. This is the old "age and area" hypothesis, rejected by most American zoogeographers. Recession and extinction are probably really very common things. I have recently discussed this point in the pages of the present journal (*Quart. Rev. Biol.*, 23: 1–2. 1948). Another assumption is that ancient geography is the *only* important factor governing animal distribution; that existing climate, for example, can be ignored. Wegenerians do consider climates, but ancient more than existing ones. A case in point from the present book (pp. 250–251) is the carabid genus *Morion*. This genus is now pan-tropical. The main existing tropical regions are about equal to ancient, hypothetical Inabresia, so *Morion* is stated to have evolved on Inabresia

and to be of Jurassic age, and it is noted as extraordinary that species of *Morion* have differentiated so little since then. That *Morion* may be limited northward and southward by existing cool climates is ignored—if its range is determined by existing climate, how can it be supposed to reflect the shape of ancient land? Still another Wegenerian assumption is that land animals never or rarely ever get across even narrow water barriers between continents, so that widely distributed animals must (by Wegener's timetable) be very old. But placental mammals, at least some rodents and many bats, have spread over every continent during the Tertiary. In the face of this fact, why is it necessary to go back to the Jurassic to account for the wide distribution of insects such as *Morion*? It is true that the bats can fly, but so can *Morion* and most other insects. It seems to me that the assumptions, and not the evidence, dictate the conclusions of this book and of Wegenerian zoogeographers in general.

It should be noted that, although fossil insects are discussed (pp. 167–194), they do *not* support the theories of the book. The book is based largely on the Carabidae and other beetles, of which the *only* important fossils are in Baltic amber, deposited in northern Europe in the early Tertiary. Many of the amber fossils stand squarely in the way of Wegenerian theories, and Wegenerians have to dispose of them or ignore them. For example, chiasognathe stag beetles (pp. 199–201) inhabit Australia, New Zealand, South America, etc., and South Africa, and so are stated to have evolved on Paleantarctica in the Jurassic. There is, however, one in Baltic amber. This fossil is supposed by some persons to show that the group was widely distributed as late as the early Tertiary and has only recently died back into southern relict areas. This idea is disposed of in the present book as "*une hypothèse toute gratuite et inadmissible*"; and the fossil is stated to indicate merely a temporary northern migration (from the other end of the world). The paussid beetles of the subfamily "Cerapteritae" (p. 250) are another case. They occur in the Australian Region, the Orient, Africa below the Sahara, and tropical America. They are stated to be Australian and Africano-Brazilian stocks of Triassic or Lower Jurassic age. The fact that they are numerous in the Baltic amber, and that *Arthropterus*, now confined to the Australian Region, is well represented in the amber is simply not mentioned in this connection and barely hinted at elsewhere (p. 193). All the dating of distributions of insects, or at least of beetles, before the Tertiary in this book is arbitrarily fitted to the Wegenerian timetable, and is not to be considered evidence for it.

The general zoogeographic background of the book is largely compiled from Scharff (1911), Arldt, and others who were uncritical compilers in the first place. It is stated (p. 99) that the only native mammals in the Australian Region are marsupials and monotremes. To ignore the many bats may possibly be excusable (although the book is largely concerned with *winged* insects), but by this time every zoogeographer should know that there are native rodents in the Australian Region, indeed many of them, including diverse endemic genera and an endemic subfamily. In proportion to the whole fauna, rodents are perhaps more numerous in the Australian Region than in any other. They make up about one-third of the native terrestrial mammal fauna there. Jeannel states (p. 99) that the Holarctic Region lacks marsupials, and forgets the well known opossum of the eastern United States. Lemurs (p. 116), chameleons (p. 344), anguid lizards (p. 115), "*Spelerpes*" salamanders (pp. 115 & 368), the New Zealand frog(s) (p. 227), and galaxiid fishes (p. 196) are all cited as having relationships or significance that it has long been known they do not have. These examples should make it clear that the background material of the book is long since out of date and thoroughly unreliable. This is hardly excusable in a book that purports to be an introduction to the elements of biogeography.

Even more disturbing than these errors are those that fall within Jeannel's special field. *Paussus* (p. 193) does not occur in the Baltic amber; it was formerly thought to do so, but the error was corrected many years ago. The specimen of *Tetracha carolina* (p. 193) in the amber is not identical with existing North American specimens; Horn made this clear in the first place (1906). Cicindelids are not absent in New Zealand (p. 229); several endemic species of *Cicindela* have long been known there. *Gehringia* (pp. 250 & 457) is not an alticoline relict localized in Montana; it was described from the Olympic Peninsula and has an extensive range at rather low altitudes in northwestern North America. *Paropisthius* (p. 255) does not inhabit peninsular India, but "North India," Sikkim, and Tibet. *Pentagonica* (p. 262) and the Helluonini (pp. 262–263, 280, 310) are well represented in the Americas as well as in the Old World. *Parallelomorpha* (p. 263) is not a member of the Helluonini; Britton, in 1937, placed it as a synonym of *Xanthophaea* in an entirely different tribe. *Catascopus* (p. 280) occurs in Africa and tropical America as well as in the places listed. *Perileptus jeanneli* (p. 369) is Jamaican, not Cuban; and other *Perileptus* species are known from Hispaniola and Puerto Rico. I have detected these errors and other less clear-cut ones because I too work on "coléoptères carabiques." My studies have touched Jeannel's in only a few cases, so this list covers a very small part of his book. Every zoogeographer may, I hope, be forgiven occasional mistakes of detail, but there are too many here.

My greatest criticism of this book is of its style. This may be partly my own fault. I read French easily, but my understanding of it may be too literal. However this may be, the book seems to me to be a suc-

cession of dogmatic statements with no distinction between fact and opinion. To some extent this will probably be obvious to most readers, but the style conceals certain things that are not so obvious. Our knowledge of the Carabidae and other beetles is not so good as the book implies. These insects are as yet not well enough collected and not well enough classified to be very important in the basic zoogeography of the world. Many of the relationships flatly asserted in the book are real, but others are doubtful, and some are mere guesses which are probably wrong, and the dogmatic style makes it impossible for most readers to tell which is which. Moreover, both the index and the bibliography are inadequate (perhaps this is not the author's fault), so that it is difficult to find all that is said about a given matter and often impossible to check the sources of doubtful statements.

For the reasons given in the preceding paragraphs, this book should not be used either as an introduction to biogeography or as a source of factual material. It is a real misfortune that it probably will be so used by botanists, geologists, and others not in a position to assess it critically.

The book is, as I have said, essentially a statement of the personal opinions of one man with great special knowledge. As such, it is important. It should be read, with suitable reservations, by persons interested in Wegenerian ideas; and parts might well be read by biologists interested in speciation, Lamarckianism, orthogenesis, or the origin of localized faunas such as those of caves and mountains. But this book might have been so much more. It could have been an impartial study of the possibilities of continental drift in the light of insect distribution. It could have been a dependable source of useful facts. It might even have been a real introduction to modern biogeography. That it is not these things is our loss, and a very great one.

REVIEWS AND BRIEF NOTICES

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GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

LOGIC AND SCIENTIFIC METHODS. *An Introductory Course.*

By Herbert L. Searles. The Ronald Press Company, New York. $3.50. xii + 326 pp.; ill. 1948.

This book will serve as a useful textbook in elementary courses in logic, this being the purpose for which it was designed. Its practicality is underwritten by the author's "many years of experience and experiment in teaching." The level of difficulty and the general approach make this book comparable to Holmes' *Rhyme of Reason* or Larrabee's *Reliable Knowledge*, rather than to Russell's *Human Knowledge* or Weyl's *Philosophy of Mathematics and Natural Science.*

The treatment of scientific methods seems, to a scientist at least, both thin and rather remote from the laboratory. Poincaré, still the most important of contributors to our knowledge of the process of scientific discovery, is not mentioned in the text. The work of Walter Reed on yellow fever is used as an example of scientific methods despite the fact that it is now known from the extensive and well documented memoir of Brigadier General Truby that it was one of the most bungled episodes in the history of an otherwise competent service.

On the whole, the volume is marked by both clarity and common sense, no mean virtues. The chapters on probability and on the use of statistics should be especially valuable. Each chapter ends with a set of problems. Answers will be found at the end of the book. There is a glossary and an excellent bibliography.

GAIRDNER MOMENT

A BRIEF BIOLOGY.

By James Watt Mavor. The Macmillan Company, New York. $4.00. viii + 427 pp.; ill. 1949.

A LABORATORY MANUAL FOR A BRIEF COURSE IN BIOLOGY.

By James Watt Mavor. The Macmillan Company, New York. $2.90 (paper). xii + 149 pp.; ill. 1949.

This abridgment of Mavor's very widely used *General Biology* textbook makes it suitable for use in a half year or quarter term course. The five sections of the

book (The Nature of Life; Plant Life; Animal Life; Human Anatomy and Physiology; and Principles) are independent enough to be interchangeable in order. There is an appendix containing a synopsis of the plant and animal kingdoms; and a glossary and an index are provided. This book will certainly appeal to many teachers and students who like Mavor's larger textbook but have regarded its stupendous growth from edition to edition with considerable apprehension.

The laboratory manual contains 14 laboratory exercises for a one-semester course, representing a selection and condensation of the author's longer *Laboratory Exercises in General Biology*. The price seems excessive.

BENTLEY GLASS

INTRODUCTORY BIOLOGY.

Edited by Andrew Stauffer. D. Van Nostrand Company, New York, Toronto and London. $5.00. x + 722 pp.; ill. 1949.

This textbook of elementary biology is designed for students in junior colleges and is a result of the cooperative efforts of ten instructors, eight of them members of the Biology Department of the Chicago City Junior College. Each of the authors has more than a dozen years of teaching experience of the subject at that level. The result is a well organized, easily readable book, one which contains very few errors of fact of any consequence. It has an adequate bibliography and the usual glossary, and is fairly well indexed. There are approximately 300 illustrations, most of which were obtained from a wide variety of sources, with very few (a dozen or so) specially prepared for the book. The authors would have done well to substitute drawings for most of the photographs in Chapters 65, 66, and 67, since a number of these do not clearly illustrate the points that they were intended to.

Aside from this, *Introductory Biology* is above the average textbook of elementary biology and may well prove popular—even outside of the Chicago City Junior College.

DAVID B. TYLER

BIOLOGY AND ITS RELATION TO MANKIND.

By A. M. Winchester. D. Van Nostrand Company, New York, Toronto and London. $5.25. x + 777 pp.; ill. 1949.

This textbook, as its title implies, covers the subject of biology "with special reference to its relation to mankind." The book is well illustrated with many original photographs. Some are particularly charming, e.g., a very interesting photograph of a snake (Fig. 27.16), a pretty effect of the sun (Fig. 34.8), and a good example of what an active program of physical exercise will succeed in doing (Fig. 31.9). Illustrations such as these do much to make for easier studying, as well as reviewing. On the whole, the text is readable.

DAVID B. TYLER

HEALTH TEACHING IN SCHOOLS *for Teachers in Elementary and Secondary Schools.*

By Ruth E. Grout. W. B. Saunders Company, Philadelphia and London. $4.00. viii + 320 pp.; ill. 1949.

This book was written for prospective teachers or for teachers in service as a basis or guide for the school health education program. The need for health instruction, and its principles and procedures are discussed. There are concrete suggestions for teaching at both elementary and secondary school levels. The importance of evaluation is emphasized. One chapter is devoted to audiovisual materials, their use in the health program, and the availability and sources from which they may be obtained. The final chapter, Coworkers in Health Education, stresses the relationships of the school health program to other community organizations, official and voluntary agencies, and professional societies. The appendix contains lists of general references and sources of health education materials, check sheets on school sanitation and on the health content of high school courses, and a teaching unit on alcohol, tobacco, and narcotic drugs. The book should be a useful supplement to the health education of the teachers themselves, to assist them in effective application and practice.

HARRIETTE D. VERA

SECONDARY-SCHOOL SCIENCE TEACHING. *A Textbook on How to Teach Science in the Junior and Senior High School.*

By Arthur G. Hoff. The Blakiston Company, Philadelphia and Toronto. $3.75. xii + 303 pp. 1947.

In the words of the author, "this book is the result of twelve years' experience as a teacher of science in the junior and senior high school and nine years in the area of training science teachers for the public secondary school. . . . An attempt was made to meet the need for a text which contains an up-to-date summary of functional information as determined by experience and research." And further, "the intention has been to give the science teacher guidance on the total area of teaching . . . the problems met with in the science classroom, . . . responsibilities relative to guidance, administration, and contact with the community. . . ." The book's five units are: The Mission of Science in Education; The Content of Science in the Secondary

School; The Function of Method in Science Teaching; Specific Techniques in Teaching Science; and Supplementary Factors in Science Teaching. An Appendix contains sample tests, a unit in biology, a unit in chemistry, and a list of equipment for general science.

The author reviews the evidence and draws the following conclusions: (1) Secondary schools need not and should not be under the dominance of college-entrance requirements in planning their science curricula. (2) Secondary-school science should relate subject matter to the problems vital to the life of the learner, which is best done by the Unit Plan of organization. (3) The use of a single basic text with its workbook, other available teaching aids, or both, makes for more efficient teaching than the use of syllabi and lengthy reading lists. (4) The keeping of formal notebooks and the making of drawings should be voluntary on the part of the students. (5) Science teaching is not yet developing in the students to any appreciable extent those scientific attitudes and that method of thinking believed to be transferable to one's daily life. (6) Science courses today contribute more extensively to the "Seven Cardinal Principles of Secondary Education" than other courses do, but they still fall quite short of making their full contribution.

It may seem strange to many persons that a textbook of science teaching should recommend that science teachers teach Sunday School classes, should give their first allegiance to the school board that hired them, should accept the decisions of the school administrator as final once such decisions have been reached (and this in schools that are supposed to be training students to wise citizenship in a democracy), and that science teachers should look upon it as part of their job to sponsor, say two, extracurricular activities, one major and one minor one. However, this insertion of advice on seemingly extraneous and personal matters may be overlooked in the light of the value of this review of the evidence in favor of progressive science teaching, a review which should prove both interesting and valuable to every serious student of the subject.

ELLA THEA SMITH

CHILDREN'S CONTRIBUTIONS IN SCIENCE DISCUSSIONS. *A Consideration of Children's Verbal Responses in Relation to Certain Objectives for Science Instruction. Teachers College, Columbia University Contributions to Education, Number 931.*

By Katherine Elizabeth Hill. Bureau of Publications, Teachers College, Columbia University, New York. $2.10. x + 96 pp. 1947.

This book reports the interesting and significant results of a rather extensive investigation of the responses of children in the first six grades to discussions and activities of a scientific character.. The investigator wanted to find out whether current aims of science teaching in the elementary grades are appropriate to children at these grade levels. During sixteen consecutive science periods in each of the first six grades, in the fall and again in the spring, all of the responses of all the children were classified in one of the following categories: Recognition of Natural Phenomena, Inquiry, Speculation, Cause and Effect Relationships, Conclusions, Recognition of Achievements of Thinking, "Critical-mindedness," "Open-mindedness," Responsibility and Cooperation, Initiative, Application of Experience, Skills, and Miscellaneous. These categories were agreed upon as current aims of elementary science teaching. Besides classifying each response, the investigator or an assistant recorded a large number of verbatim remarks by students.

Careful analysis of the findings shows that students in every grade made responses in every category. In all categories except Conclusions and the Recognition of Achievements of Thinking, the number of responses was astonishingly large. More than eighty per cent of the children made responses related to the first four categories. The findings seem to indicate that the current objectives of elementary science teaching, as listed by the author, are appropriate to students at these grade levels. Even first graders are capable of "critical-mindedness" and "open-mindedness" (60 per cent made responses of the former and 73 per cent of the latter category). It was found, furthermore, that more responses showing Responsibility, Initiative, Application of Experience, and Skills were made when students were using experimental materials than when mere discussion was carried on.

This book should prove of real value, both to elementary teachers and to those concerned with curriculum-making for the first six grades. If science teaching is ever to realize its full value in "enriching life," it may well, and perhaps must, begin with the child's first school experience and continue throughout his school career. The old excuse of some educators that children "are not old enough to assume responsibility" would seem to be disproved by this investigation.

ELLA THEA SMITH

FILM AND EDUCATION. *A Symposium on the Role of the Film in the Field of Education.*

Edited by Godfrey M. Elliott. Philosophical Library, New York. $7.50. xii + 597 pp. 1948.

Thirty-seven writers have cooperated "to present within the useful limits of one volume a comprehensive survey of the present and potential uses of the 16 mm. educational motion picture in our modern society," employing the word education in its broader sense, to include schooling and training, formal or informal, in or out of school.

An opening chapter by the editor traces the origins of the educational film in the efforts of Eadweard Muybridge, Etienne Jules Marey, and a few others toward the end of the 19th century. Twelve types of educational films are distinguished by function: narrative, dramatic, discoursive, evidential, factual (including "documentary"), emulative, problematic, incentive (including many commonly called "documentaries"), rhythmic, therapeutic, drill, and participative. Basic techniques in film use are discussed, and further chapters detail the experience of the various cooperating authors in applications of educational films in science, mathematics, language, art, guidance, training of sales personnel, and so on. Considerable space is given to considerations of educational film libraries under various types of sponsorship, and how these may best serve community needs. Many of the most successful films are mentioned by name, and included in the good index.

The book comes close to fulfilling the high hopes expressed in its preface and should be helpful reading for anyone concerned with use of the 16 mm. medium in education. The typography and binding are attractive, but for a book without pictures the price seems discouragingly high.

LORUS J. & MARGERY J. MILNE

SCIENCE AND THE NATION. *Pelican Books.* *By Members of the Association of Scientific Workers. Penguin Books, Harmondsworth, Middlesex.* 1s. (paper). 249 pp. 1947.

This book, a best-seller in England, may be aptly likened to *Science: the Endless Frontier* (Report to the President by OSRD) and *Endless Horizons*, both written by Vannevar Bush; for the British and the American books alike grew out of the enormous use and value of science in solving the practical problems of warfare in World War II. The books differ considerably, however, in their methods of analysis. The approach used by the Americans was to consider the relation of science to government, to use the need for coordinated effort in the war on disease as an example, to emphasize the importance of basic research in science, and then to attack the problems of the renewal of scientific talent and of scientific reconversion after the war so as to arrive at specific recommendations for a National Science Foundation to achieve the ends desired. The British scientists cooperating in writing this report have proceeded, first, to survey the key industries of Britain and the needs for planning, both social and scientific, in each of them (fuel and power; heavy chemicals; engineering, transport, and communications; agriculture; plastics and fermentations; health and the medical services; food and consumer goods industries; building and home design). It is only after the needs in each area have been thoroughly surveyed that the analysis passes to a consideration of Consumer Research and How to Assess our Requirements, Problems in Administration, and the Future of Fundamental Research in Science. Although the British agree with the Americans as to the fundamental significance of basic research, they have not tried to elaborate a rather grandiose National Science Foundation, which may fail for political reasons. Instead, they have preferred to recommend a separation of functions. A University Research Committee would coordinate research in the universities and focus it upon critical problems. A University Grants Committee would allocate funds, with the advice of a Universities Council representing all the universities. A Medical Research Council and an Agricultural Research Council and the Department of Scientific and Industrial Research, already in existence and well-tried, would carry on, the first two merging to form a Biological Research Council, and the D. S. I. R. being transformed into a Physical Research Council. An entirely new Social Research Council would be formed to complete the triad. These councils would be represented in the government at the Cabinet Secretariat level by a Central Scientific Office, to be both administrative and scientific in function and personnel.

A chapter on Facilities for Scientific Research is of general interest to scientists. The proposals made for the extension of facilities to increase the mobility of scientists, between industry and the universities on the one hand, and internationally on the other, might well be considered in the United States. The grave problems involved in disseminating scientific knowledge may be met, it is hoped, by rationalizing the publication of scientific papers, the printing and distribution of reprints, and the support and coordination of abstract journals, by setting up a scientific information service, and by forming a central Science Publishing Organization to handle editing and publication uniformly.

The next two chapters deal with the cultural value of science and its role in general education. These do not seem to be particularly revolutionary. The chapter on the Training of Scientists and the numbers of scientists needed is a thorough analysis, with important recommendations. The book ends with an essay on The Politics of Science which is thought-provoking. All in all, the book is well balanced and deserves the most careful consideration by all scientists interested in the problem of the relation of the state to the encouragement or control of science—as what scientist is not? The radical views of certain British members of the Association of Scientific Workers, of which P. M. S. Blackett was President at the time this report to the nation was drafted, do not seem to have forced conclusions to unwarranted extremes. If the

British people can apply even a part of the program mapped here, the resulting improvement of science might well help to mitigate, or even abolish, those economic troubles that now distress the nation. But of course it will take time. Is it not true that the crucial question, in England, here in the United States, and in all the Western democracies, is whether a people living in a political democracy can look far enough ahead to plan for the future a generation hence, even at considerable present cost?

BENTLEY GLASS

NEW BIOLOGY. *Numbers 5 and 6.*

Edited by M. L. Johnson and Michael Abercrombie. Penguin Books, Harmondsworth, Middlesex. 1s. 6d. each (paper). 130 pp. + 11 plates; 128 pp. + 16 plates; text ill. 1948; 1949.

Contents: 5. Blue-green Algae (G. E. Fogg); Structure and Function in the Living Cell (John E. Harris); Plant Growth-Regulating Substances (Thomas Swarbrick); Man's Ancestry (J. S. Weiner); The Study of the Behaviour of Mammals (Anthony Barnett); From Egg to Adult (Michael Abercrombie). 6. The English Lakes and their Development (W. H. Pearsall); The Slugs in our Gardens (H. F. Barnes); Grassland Agronomy (W. Davies); On Breaking a Bone (N. A. Barnicot); Famous Plants—1. *Volvox* (F. W. Jane); Famous Animals—1. *Hydra* (R. F. Ewer); New Light on the Origin of the Vertebrates (D. R. Newth); Life Cycle of the Malaria Parasite (M. L. Johnson).

The value of such articles to biologists who wish to keep up with what is going on outside their own immediate fields is very great. For teachers of biology the articles on *Volvox*, *Hydra*, and the blue-green algae are particularly worth-while. No one should miss the newsworthy short reports on (1) a well preserved fossil cephalochordate (*Jamoytius*) from the Silurian, or (2) the large exo-erythrocyte stages of *Plasmodium* (25–30 μ in diam.), now discovered to exist in the livers of malarial monkeys and human beings and shown to be an important phase of the life cycle of the parasite.

BENTLEY GLASS

BIOLOGY: HISTORY AND BIOGRAPHY

THE BEGINNINGS OF MODERN SCIENCE. *Scientific Writings of the 16th, 17th and 18th Centuries.*

Edited by Holmes Boynton. Published for the Classics Club by Walter J. Black, New York. $2.89. xxii + 634 pp.; text ill. 1948.

Without question, this is as fine an anthology of science as has been compiled. Many of the selections are, it is true, available in similar books, but many others are not readily found anywhere. The editor has very wisely confined the scope of the anthology within limits of time rather than subject. By choosing the earlier part of the development of modern science and stopping at the end of the 18th century, it has been possible to show the broadness of the early scientists whose philosophy of nature led them into many fields. How many biologists, for example, are aware that Robert Hooke, whom they know as the author of the admirable *Micrographia* and the discoverer of cells in living organisms, was also the inventor of the projection lantern and of the spring scale for measuring weight, two devices they use nearly every day? In this collection of scientific writings, one may not only learn that this is so, but may read and compare the two less familiar of the three original communications. It is also intensely interesting to follow the development of certain scientific concepts during the two or three centuries from the beginnings of modern science to 1800. This is possible because the chosen classics of early science are grouped so as to achieve unity of subject while at the same time they show the chronological development of the major scientific concepts.

This may be readily grasped from a list of the main groups, together with a detailed indication of the content of one or two of them, as follows: I. Matter and Motion; II. Light, Heat, and Fire; III. The Study of Air and of Chemistry; IV. Electricity; V. The Earth and Its Waters; VI. How Plants Grow; VII. The Structure of the Human Body; VIII. The Science of Healing; IX. Scientists Think About Science. Under VI we find: Is Wood Made of Water? (J. B. van Helmont); Description of Plants (Nehemiah Grew); The Pressure of Sap in Plants (Stephen Hales); A Dissertation on the Sexes of Plants (Linnaeus); On Classification of Plants (Linnaeus); Of the Restoration of Air Infected by Animal Respiration (Joseph Priestley); and The Breathing of Plants (Jan Ingenhousz). In the last group (IX) are; Arts and Sciences a Miner Must Know (Agricola); Conduct of the Investigation of Nature (Francis Bacon); Of the Principles of Human Knowledge (René Descartes); Rules of Reasoning in Philosophy (Isaac Newton); Reasoning and Language (Antoine Lavoisier); and Probabilities and Natural Philosophy (P. S. de Laplace). Within the other two groups of biological essays the reader will meet Vesalius, Servetus, Fabricius, Harvey, Leeuwenhoek, and Spallanzani; Fracastorius, Paré, Sydenham, Lady Mary Wortley Montagu, Auenbrugger, James Cook, and Edward Jenner.

Yet perhaps the greatest interest and value of this book for the biologist will spring from his thoughts as he explores the other groups of writings and finds Buffon juxtaposed to Benjamin Franklin and James Hutton, or sees the relation between Galvani's physiological explorations of the newly tamed electricity and Volta's development of the first electric battery. No

experience can be more calculated to open the eyes of a modern experimenter to the limitations of his specialization and the narrowness of his vision.

If this book cost ten times its modest price, it would be worth every cent of it. For the beginner in science, it is a fine historical introduction; for the mature scientist it is a thought-provoking excursion outside his habitual round; for the teacher of any science it is a mine of excellent illustrations and memorable demonstrations.

BENTLEY GLASS

THE AUTOBIOGRAPHY OF BENJAMIN RUSH: *His "Travels Through Life" together with his Commonplace Book for 1789–1813. Memoirs of The American Philosophical Society, Volume 25.*

Edited with introduction and notes by George W. Corner. The American Philosophical Society, Philadelphia; Princeton University Press, Princeton. $6.00. viii + 399 pp. + 9 plates. 1948.

"These pages," according to their editor's eminently just evaluation of them, "reveal the intimate thoughts of a brave, patriotic, and humane man. . . . He has been called wise, and again foolish; generous, and egotistic; a genius and an intellectual fumbler; a scientific materialist and a believer in revealed religion. That he was all of these at once is shown by the intimate records here printed. To withhold any word of them is to lessen the comprehension which, more than praise or adulation, we owe to the memory of a great man."

The volume includes Rush's autobiographical *Travels through Life*, begun in 1800, and two *Commonplace Books*, one covering the years 1789–1791, the other 1792–1813. Rush summed himself up, in the fascinating "Characters of the Revolutionary Patriots" included in the autobiography, by the terse comment that "he aimed well." The autobiography, written, he claimed, for the use of his children, together with the notebooks, reveals what he thought his aims to be and something of the method of their accomplishment, the measure of which can be gauged on the technical side by Rush's position in the 18th century American medicine, and more broadly by the continuing success of the political experiment the beginnings of which he was so instrumental in initiating.

His high degree of versatility and great breadth of interest are in some ways perhaps less vividly portrayed here than in his other publications; yet a recognition of his own attitude towards his activities is indispensable to their understanding. His descriptions of his "medical apprenticeship and study abroad," of his "life as a physician in Philadelphia," and of his political and military experiences in the formative days of the Republic will be of particular interest to all who are interested in this period from the medical, social, literary, or political points of view.

His directness and simplicity of style in these writings are delightful, and will be especially agreeable to those who have become accustomed to the more turgid 18th century periods which characterize his more formal publications. This book, which is so beautifully printed and illustrated, and which has been edited and annotated with such great competence and imagination by George W. Corner, merits careful attention from all who share Rush's conviction that the American Revolution was "big with important consequences to the world, and that the labor of no individual, however feeble his contributions to it were, could have been spared." Rush's own contribution was a strong one, and we owe to his memory a full consideration of their value.

JANE OPPENHEIMER

CLAUDE BERNARD ET LA PHYSIOLOGIE. *Les Batisseurs de la Science Moderne, II.*

By W. Kopaczewski. Published by the author, Rabat, Morocco; Gautier-Villars, Paris. 250 fr. (paper). viii + 84 pp. + 2 plates. 1945.

The position of Claude Bernard with reference to physiology and medicine before and after his day is discussed once more in this small, popular biography. Bernard's contributions are described adequately, but not particularly outstandingly, and with a fair degree of accuracy. The author tends to overemphasize the value of Bernard's views on the mechanism of fermentation, where he stood in disagreement with Pasteur. The discussion might well have been fuller with reference to the biological implications of the doctrine of the constancy of the internal environment, and with respect to the philosophical implications of Bernard's determinism. Be that as it may, attempts such as this to popularize the teachings and teachers of science, attempts apparently so much more in demand in the French-speaking countries than here, form part of a tradition that American scientific writers might well emulate.

JANE OPPENHEIMER

THE GREEN WORLD OF THE NATURALISTS. *A Treasury of Five Centuries of Natural History in South America. By Victor Wolfgang von Hagen. Greenberg, New York.* $5.00. xx + 392 pp. 1948.

Victor Wolfgang von Hagen has written many books about the natural history and ethnology of South America and about the naturalists and explorers who have made that continent known. In this book,

except for brief biographical notes, he lets the naturalists speak for themselves. Without intending any disparagement, it is clear that the outcome is a very happy one.

The selections are arranged chronologically, beginning with five explorers of the 16th century, of whom Oviedo and Acosta had most to tell of the flora and fauna of the New World. The 17th century is represented by a couple of buccaneers. First was Lionel Wafer, a ship's surgeon, who wrote vividly of the strange plants and animals of Panama, but seems to have mistaken the back-gland of the peccary for its navel, to his own considerable consternation. Second was William Dampier, represented here by a classic account of the manatees, seals and sea lions, and marine turtles.

The 18th century gives us Antonio de Ulloa's description of the tropical vegetation around Cartagena; the notable account of quinine, rubber, and curare, by la Condamine; a graphic, early sketch of the pampas and the wild horses there, by Félix de Azara; and finally, a selection from the epochal story of his travels written by von Humboldt at the turn of the century. This, happily, is the account of the great cavern of the Guacharo in Venezuela and, afterwards, of the electric eels.

Of the 19th century naturalists, Charles Darwin of course takes precedence. He is represented by a part of his account of Tierra del Fuego, extracted from the *Voyage of the Beagle*. D'Orbigny's vivid relation of his trip from the llanos of northeastern Bolivia up over the Andes to Cochabamba will be unforgettable, but no less could be said of Herman Melville's description of the desolate Galapagos, Alfred Russel Wallace's depiction of the tropical jungle of the Amazon, Bates' account of leaf-cutting and army ants, Richard Spruce's voyage on the middle Amazon, or Edward Whymper's ascent and overnight stay on the brim of the great volcano Cotopaxi.

To expect the naturalists of the 20th century to equal such tales as these is almost to require the impossible, and yet they do worthily, with William Henry Hudson's moody, atmospheric word-painting of Patagonia and the brightly splashed sentences of William Beebe to lead off. A bit from Tomlinson's musical analysis of the sounds of the birds and the voices of the frogs in Brazil, and three selections by Frank M. Chapman, Robert Cushman Murphy, and Ivan Sanderson, respectively, conclude the journey. Next to a trip to South America yourself, try an excursion in *The Green World of the Naturalists*. But you are warned—it will inevitably make you want to go and see for yourself that great and varied continent, so rich in interest for every naturalist.

BENTLEY GLASS

RUTH FULTON BENEDICT. *A Memorial.*

Viking Fund, New York. Free upon request (paper). 47 pp.; ill. 1949.

Frontispiece, a sketch of Ruth Benedict by Erik Erikson; memorial speeches by Alfred Kroeber, Cora DuBois, Erik Erikson, Clyde Kluckhohn, Robert Lynd, and Margaret Mead; a Minute presented at Columbia University; a chronology of Ruth Benedict's life; and a bibliography of her works, compiled by Mary E. Chandler.

ECOLOGY AND NATURAL HISTORY

NATURE FOR ALL. *Trees, Flowers, Mammals, Birds, Fish, Reptiles, Amphibians, Insects. Everyday Handbook Series.*

By Duane Featherstonhaugh. Barnes & Noble, New York. 75 cents (paper). vi + 136 pp.; ill. 1948.

Professional biologists will not be impressed greatly with this attempt to interest the general reader in natural history. The treatment is uneven; straightforward description of one form after another gives way in some places to trivial details, in others to sudden spurts of scientific terminology, such as taxonomic categories. Those for whom the pocket-size book seems intended will be unlikely to appreciate the value of the words STEGANOPODES, Acanthopterygii and so on, or to recognize much evidence for the following caption under a photograph of a duck: "The fact that birds are descended from reptiles can be seen in the neck and head of the common duck. The scientific name, *Anseres*, means 'serpent-like'." There is an index.

LORUS J. & MARGERY J. MILNE

MARCHING WITH THE GRASSES.

By Raymond J. Pool. University of Nebraska Press, Lincoln. $3.50. xii + 210 pp. + 5 maps; text ill. 1948.

This is a book written for the non-technical reader. It is stated to contain material useful for the "students and teachers of general science, botany, agriculture, biology, agronomy, geography, sociology, commerce, and history . . . ." The principal grasslands of the world, the principal food grains, and the grasses of the ranges, pastures, and meadows and lawns are discussed. There is a chapter on grasses in relation to soil conservation and a chapter on miscellaneous interests in grasses. Brief comments on the origins in time and place of each of the grasses is given. Maps showing the general distribution of the grains and their centers of production are abundant. There are numerous data on production, together with a simple discussion of the rela-

tion of the grasses to the soils and climates, and in the case of the food grains, of some of the reasons for export, import, or both. There is a bibliography and an index.

Because this material is intended for the non-specialist and aimed at a wide area of students, it is quite elementary for anyone with any particular interest in any of the grasses. Although the author has tried to make the work light and interesting for the general reader, it tends to lapse into considerations of "millions of bushels" after too brief a skirmish with the more interesting roles of these plants in the history of man.

GEORGE F. CARTER

THE OCEAN. *The Home University Library of Modern Knowledge, Number 203.*

By F. D. Ommanney. Geoffrey Cumberlege, Oxford University Press, London, New York, Toronto. $1.50. x + 238 pp.; ill. 1949.

This little book is the successor to Sir John Murray's book written for the same series, a book which, when it was published nearly forty years ago, was the finest and most comprehensive popular summary of its subject ever prepared. Ommaney's *Ocean*, while not buttressed by the overwhelming weight of so eminent an authority, is a worthy successor to Sir John's brief volume. While it has fewer pages, it is printed in smaller type and covers several topics that were not considered in detail in its predecessor, topics such as sea fisheries, whaling, and the biology of the seashore. In only one respect does it fail to measure up, and that is in its illustrations. Although serviceable, they are not quite as well done as those of its foregoer, and they are far too sparse. A few, such as that of the pteropod, seem to have been drawn from preserved material. Nevertheless, the book stands as the best buy on the present market for those who wish to be introduced to the vast field of oceanography, and its brief bibliography is a clear signpost to further reading.

JOEL W. HEDGPETH

SEASHORE TREASURES.

By Charles Howard Edmondson. Pacific Books, Palo Alto. $3.50. 144 pp.; ill. 1949.

BEGINNER'S GUIDE TO SEASHORE LIFE.

By Leon A. Hausman. G. P. Putnam's Sons, New York. $2.00. 128 pp.; ill. 1949.

These two small books are excellent examples, respectively, of how and how not to write a seashore book. Since P. H. Gosse first began to write seashore books about a hundred years ago, there has been at least one such book, and often several, published every year. The total is now in the hundreds in the English language alone, many of them being intended for children. With all these examples on the shelves of libraries and second-hand bookstores, the least we can desire, among the new ones, is a book like Edmondson's, intended for the children for Hawaii. While it is not ornamented with color plates and could have been improved by photographs of the animals in their natural setting, it does have fine scenes of Hawaiian beaches and serviceable photographs of the animals mentioned. The text is on the whole excellent for its purpose, conveying an understanding of the intricacies of zoology and the biology of the seashore in simple terms.

Hausman's little book, to the contrary, reveals almost no understanding of the seashore and a haphazard knowledge of zoology that is surprising in a professor of zoology. The book consists of two pages of introductory text, doing little more than outline the book, plus a "simplified key to the natural groups of seashore animals," which is a mere rough synopsis, and thumbnail descriptions of common seashore animals and plants. These descriptions are accompanied by some of the most inept, amateurish drawings (especially of bryozoans and hydroids ever included in a work of this type. They are inadequate for purposes of identification even when not erroneous, and the text is marred by personally contrived, inaccurate common names, such as sea spider for spider crab.

Edmondson has made no effort to provide common names when these do not exist, but has given many Hawaiian names for those animals known to the natives. In short, as to these two books, the younger beginners and beachcombers of Hawaii are much more fortunate than their fellows along the Atlantic seaboard in every way save price. If Edmondson's book seems priced just a little high, Hausman's is worth considerably less than half the price asked by the publishers. It should be an early candidate for the remainder tables.

JOEL W. HEDGPETH

MAKING FRIENDS WITH BIRDS.

By Arthur F. Park. Chatto and Windus, London. 21s. xii + 216 pp.; ill. 1948.

Two features distinguish this book—the excellent, gravure-style reproductions of clear photographs, and the seeming casualness with which all manner of birds sit on the photographer's fingers or a few inches distant while he records their portraits. One cannot help wondering whether British birds are any less concerned over possible human persecution than those of comparably settled areas in America. It is only in remote areas, far from habitations, that the reviewers have encountered a similar unconcern among the feathered fauna. But photographer Park assures us that "contact with the hand once established, the battle is prac-

tically won, and the rest is only a matter of time and patience." His demonstrations of the method remove this statement from the realm of the salt-on-the-tail recipe for catching small birds. He notes that when several of the same kind have been "tamed" in this free sense, "to a stranger, they all looked as alike as peas in a pod, but I could easily distinguish them, for each had a distinct personality and mannerisms." Under such circumstances, the pictures of nests and nestlings take on a new significance. Only one shot (of a reed bunting adult) was taken by means of a longer than normal lens. For the most part the photographic problems seem to have been those of finding cameras focusing to 3 feet or nearer, of using portrait lenses, and so on—the enlargement on the film being achieved through proximity to the subject.

The handsome format and illustrations and the interesting text should make this book popular and useful among ornithologists and wildlife photographers. There is a table giving details for each picture taken, but there is no index to the birds described.

LORUS J. & MARGERY J. MILNE

LES SCÈNES DE LA VIE ANIMALE.

By Léon Binet. Gallimard, Paris. 135 fr. (paper). 236 pp. + 14 plates; text ill. 1946.

The writer of this captivating little book has assembled within its pages a diverting account of the wonders of a naturalist's world. In our present age of scientific specialization there are few people capable of ranging competently over the separate disciplines of biology. Professor Binet has only partially succeeded. It is the undercurrent of Gallic charm that creates for the reader a unique and worthwhile atmosphere.

A central theme emerges in the early chapters. If the patterns of behavior, or the physiological and morphological peculiarities of an animal species make it an object of particular interest and curiosity, then it becomes fair game for Léon Binet's collection of zoological oddities. Since the author has travelled widely and is a keen observer, his comments have an authenticity not found in books compiled by simple reference to the literature. A survey of selected subjects will serve to give some idea of the material drawn upon for discussion. There are accounts of luminosity in animals, courtship and mating behavior, longevity, pigmentation, ecology, and discursions into the natural history and biology of cats, snails, bats, insects, fishes, birds, and many other forms of life. Eight text figures and fourteen photographic plates supplement the text.

It is interesting to compare *Les Scènes de la Vie Animale* with Marcel Florkin's *Biochemical Evolution*. Both draw attention to the parallels and differences that characterize animal species. Between the two lies the gulf that separates the naturalist from the modern biochemist. Binet has relatively less real scientific information to impart. His book will find its audience among those who can appreciate the observations of a genial and mature mind on many members of the zoological fraternity, with emphasis upon entertainment rather than instruction.

VERNON BRYSON

STUDIES ON THE LIFE HISTORY OF ELEUTHERODACTYLUS RICORDII PLANIROSTRIS (COPE) IN FLORIDA. *With Special Reference to the Local Distribution of an Allelomorphic Color Pattern. University of Florida Studies, Biological Science Series, Volume IV, Number 2.*

By Coleman J. Goin. University of Florida Press, Gainesville. $1.60 (paper). xii + 66 pp.; ill. 1947.

It has been easier for the elder systematists in zoology to preach to their younger colleagues about the desirability of engaging in the "New Systematics" than to practice their preaching. The new systematics requires merely a consideration of the biological subsciences that have grown up independently since the turn of the century, and the use of techniques of study that have become available or better understood during the same period. It is especially the specialized science of genetics and the generalized and synthetic science of ecology that need to be brought to bear on the problems of systematics.

It is gratifying to have an example of precisely this kind of study in Goin's paper, for in it the life history of a remarkable species of frog is examined critically and ecologically, and the variation of the species is examined in the light of genetics.

The 100-odd species of frogs of the genus *Eleutherodactylus* of tropical America are remarkable in that, as far as is known, all of them lay their eggs out of water, with nearly direct development into the adult form, and with varying degrees of brood care by one or the other parent. To zoologists of temperate regions this is a most novel mode of life-history for a frog, and it is not surprising that the egg-laying and development in *Eleutherodactylus* have received widespread attention from naturalists since it was first reported (for the common Puerto Rican species) in 1871. As Goin's study well shows, it is high time that exclamations of wonder at this remarkable and indeed fascinating phenomenon should be supplemented by critical study.

The studies in the paper under review are brought to bear on the problems of variation and geographic distribution of the species and thus form a sound contribution to modern systematics and ecology.

KARL P. SCHMIDT

EVOLUTION

BIOGRAPHY OF THE EARTH. *Its Past, Present and Future.*

By George Gamow. A Pelican Mentor Book, The New American Library, New York. 35 cents (paper). xiv + 194 pp. + 12 plates; text ill. 1948.

This is a reprint of the original edition, published in 1941, but with the addition of a section, Laplace Was Right After All, from the author's latest book, *One, Two, Three . . . Infinity.* The new section recounts the latest somersault in the ideas of astronomers about the origin of the solar system. Considering that the rather positive statements and logical reasoning of the author, leading to the elimination of the Laplacian hypothesis, have not been altered in the preceding sections, this makes rather amusing reading.

Biologists will be particularly interested in the last four chapters (The Evolution of Continents; Climates of the Past; Life on the Earth; and A Glimpse into the Future), which graphically portray the story of organic evolution in its geologic setting.

BENTLEY GLASS

PERMIAN CRINOID CALCEOLISPONGIA. *The Geological Society of America Memoir 34.*

By Curt Teichert. The Geological Society of America, New York. $2.50. x + 132 pp. + 25 plates + 1 chart; text ill. 1949.

Teichert's demonstration of the orthogenetic evolution of the Permian sealily *Calceolispongia* (once believed to be a sponge) is astonishing, and may be safely considered one of the classical paleontological monographs of our time. Examples have been known of a rapid (in a geological sense) phyletic increase of size in invertebrates, such as foraminifera of the *Fusulina* and *Orbitolina* stocks, the bryozoan *Fenestella*, the cephalopod *Baculites*, and others; but crinoids were known to keep their average size rather well stabilized through geological time and up to the present. The evolution of *Calceolispongia* not only upsets this concept, but seemingly sets a new record for rapidity of evolutionary size increment for any animal or any geological time. Teichert calculates that during its course of evolution in a period of some 6,000,000 years the basal plates in the calyx of *Calceolispongia* increased in bulk 40,000 per cent. His graph (Pl. 26) shows an overall size of the calyx increased about 8 times during the same lapse of time. By comparison, fusulines increased in size only about two times in the course of all Permian time, about 30,000,000 years. The height of horses increased only 3 times in the course of the Tertiary, estimated at 60,000,000 years (some now make it 70,000,000). Besides this, both fusulines and horses suffered very considerable evolutionary changes in structure, but no visible change of this kind can be observed in *Calceolispongia*, whose stability in organization in spite of its extraordinary increase in size seems to be without parallel among the fossil organisms known to science.

It is difficult to enumerate in a short review all the many useful and novel ways of treatment of the described fossil which make the work by Teichert stand out among contemporary papers on fossil crinoids. Most important seems his investigation of the anatomy of the calcareous plates, the "nervous system" of which he finds fashioned much like that in the Cretaceous *Marsupites*—a study habitually neglected by students of American paleozoic crinoids (see Q. R. B., 21: 185. 1946). Teichert rejects the treatment of their structure as a sort of geometric object, and avoids using the elaborate system of numbering the plates (that make up the "head" or calyx of a fossil crinoid). He approaches the study of fossil crinoids as a biologist—a most welcome step!

A critic would be at a loss to find any shortcomings in the excellently balanced paleobiological as well as geological treatment of the subject here. He might question only the propriety of using the term "gigantism" for this (or any other cases) of a normal "phyletic growth in size" in organisms, termed so in the first comprehensive treatment of the phenomenon by Deperet. Russian zoological geneticists propose to distinguish normal phyletic or orthogenetic increase in size (Schmalhausen, 1946, pp. 450, 475–480) from racially harmful, non-adaptive "over-development" accompanied by growth in size, which they term "hypermorphosis." True biologic gigantism as well as dwarfing have been recognized among fossil organisms (Muir-Wood, 1928, and others), and the use of these terms should be accordingly restricted. The orthogenetic evolution of *Calceolispongia*, as expressed in a rather harmonious progressive increase both of its overall size and its massive spines, has apparently done no harm to the genus, which continued to be dominant in the inland seas of Gondwanaland for some 6,000,000 years, after which time it was seemingly wiped out by a physio-geographic change at the end of the Wandagee epoch. Teichert himself rejects the idea of "racial senescence" as a cause of its extinction, pointing out that the last species, *C. robusta*, "is also the longest-lived." It seems, indeed, that it was Haldane (1939) who made the original error in applying the old biological term gigantism to a phylogenetic increase in size, which he believed to be "the result of intraspecific competition." But Teichert finds that Haldane's explanation does not hold for the evolution of *Calceolispongia*, and thus it seems even less probable in the common cases of moderate phyletic growth in size.

M. K. ELIAS

ACANTHOCERATID AMMONOIDEA FROM NEAR GREYBULL, WYOMING. *Bulletin of the American Museum of Natural History, Volume 93: Article 1.*

By Otto Haas. American Museum of Natural History, New York. $1.35 (paper). Pp. 1–40 + 15 plates; text ill. 1949.

The study of ammonites is admittedly one of the most difficult in paleontology, and in our time has become even more complex since ideas of the evolution of at least certain features in these (and other) fossil animals by neoteny (coenogenesis, or proterogenesis) instead of by classical recapitulation have been worked out (particularly by Spath and Schindewolf). It is fortunate for America to have in Otto Haas a highly trained specialist on the Mesozoic ammonites, particularly in view of our recent losses in this field of research through death (Gayle Scott), administrative duties (Reeside), or other reasons (Crickway, Adkins).

The study and revision of the acanthoceratid Ammonoidea is the second venture by Haas into the study of material from the Middle West, and it serves to link taxonomically and stratigraphically our Cretaceous marine forms with those in the classical region of England and western Europe, on one hand, and that of Angola on the other. Species of three important genera, *Mantelliceras*, *Metoicoceras*, and *Dunveganoceras*, all from the upper Cretaceous correlated with the Cenomanian and Turonian of Europe, are described here in detail, and their relationships to the identical and closely related forms from elsewhere are skilfully analysed. The author proceeds with caution and avoids premature sweeping generalizations, a prudent start in the work on our Mid-western forms that ought to insure results of lasting value.

The seemingly "remarkable . . . complete absence of the genus *Baculites*" as well as that of *Scaphites* in the fauna studied is probably an accidental result of incomplete collecting from the formation. In the Upper Cretaceous of the Midwest only a few genera of ammonites, such as *Scaphites*, *Discoscaphites*, and *Acanthoscaphites* mingle with *Baculites*, and the genera of larger coiled ammonites do not. These form different assemblages that apparently indicate somewhat different environments.

It seems that painting the intervals between the suture lines, a practice which many students of ammonoids favor, would be advantageous in this work, at least for some of the material illustrated by Haas. Otherwise his photographs and drawings of sutures are among the best and most accurate in the recent publications on the subject.

M. K. ELIAS

ORIGINS OF THE FLORA OF CALIFORNIA. *Stanford University Publications, University Series. Biological Sciences, Volume X, Number 1.*

By Douglas H. Campbell and Ira L. Wiggins. Stanford University Press, Stanford University; Geoffrey Cumberlege, Oxford University Press, London. 50 cents (paper). 20 pp. 1947.

GENETICS AND CYTOLOGY

THE WHOLE LIFE CYCLE OF CHROMOSOMES AND THEIR COILING SYSTEMS. *Transactions of the American Philosophical Society Held at Philadelphia for Promoting Useful Knowledge. New Series, Volume 39, Part 1, 1949.*

By L. R. Cleveland. The American Philosophical Society, Philadelphia. $1.50 (paper). ii + 100 pp.; ill. 1949.

Cytologists who are interested in the structure of coiled chromosomes have long disagreed in their interpretations of it and speculation as to its nature and causes. These differences of opinion originate both in the initial premises dealing with the number and disposition of the chromonemata at particular stages of the dividing cell and in the difficulties of observation, which are usually at the lower resolving limits of the light microscope. It has been stated, somewhat facetiously to be sure, but not without some grain of truth, that each investigator has seen in his own material only what he wished to see. Lately, however, the observations of Sparrow, Ris, Keeffe, and others, made on *Trillium*, *Tradescantia*, and various orthopterans, have suggested an underlying similarity in all coiling systems, and it has seemed that a reasonably accurate description of the coiling cycle has been made, with the variations, which are to be expected, being matters of degree and timing but not of kind. The Protozoa have figured not at all in either the controversy or its apparent solution. Now it appears that a good object for study had been missed, for Cleveland has shown that the intestinal Protozoa, and in particular the 2-chromosome species of the genus *Holomastigotoides* of the wood-eating Prorhinotermes, provide excellent material for cytological study. Several striking and unusual facts are brought out in this monograph, and it will be well to enumerate them briefly:

1. The chromosomes are visible throughout the entire cycle of cell division, there being no interphase of the customary sort with its diffuse chromatin. The resting stage occurs in late prophase, while the fully contracted chromosomes are clearly visible, but in a state of suspended development.

2. The centromeres of both chromosomes are truly terminal, and they are often separated from the body of the chromosome by a slender thread of some 15 or more microns in length. The centromeres, except for a brief time in early telophase, are always connected to the nuclear membrane and to the centrioles.

3. The achromatic figure, rectangular or square in shape rather than biacuminate, is fully formed by late telophase, and persists unchanged through the late prophase resting stage into metaphase. The centromeres, as a result, are clearly separated by late telophase. Anaphase movement is accomplished by an elongation of the spindle.

4. Minor coils persist throughout all stages of cell division, and never disappear. As many as three hundred minor coils may be present on a single chromosome, and the author expresses the belief that these are an expression of the molecular structure of the chromosome.

5. Unlike the minor coils, the major coils are renewed at each prophase, being thrown upon the minor coils by the contraction of the visibly distinct matrices of the chromosomes. A third order of coils, the supercoils, may be thrown upon the majors if contraction of the matrix is extreme. Contrary to the generally accepted thesis that the meiotic and mitotic gyres become fewer in number and larger in diameter as prophase progresses, the chromosomes of these Protozoa undergo no change in coil size or number once the coils have become established.

6. Some forms of Protozoa studied show only a chromatid split in prophase, whereas others reveal an additional division that produces visibly separate half-chromatids.

The descriptive data, illustrated with 93 beautifully executed drawings, leave no doubt in the mind of the reader that these protozoans lend themselves very well to a critical analysis of the coiling cycle of chromosomes. They can no longer be disregarded in any interpretation of chromosome systems, as White has done in his recent book. On the other hand, it is difficult in the light of recent evidence to do other than regard the coiling cycle of these Protozoa as a specialized type of chromosome contraction which is arrived at through a different evolutionary channel than that followed by higher organisms. The lack of an interphase with diffuse chromatin, the late prophase resting stage which may last for weeks, the ever-present minor coils, the terminal centromeres with persistent centriolar attachment, and the peculiar spindle formation and timing set these forms cytologically apart, and one cannot at present wholeheartedly agree with the author that observations from other organisms will eventually fall into the line with the protozoan data.

The author has had a unique opportunity to discuss his significant findings in terms of current ideas on chromosome coiling, but this he has failed to do, Sparrow's 1942 paper being the only citation of the literature which deals specifically with the subject. The monograph, in fact, is marred by an uncritical, discrediting discussion quite out of keeping with the excellence of the descriptive data. The author's statement that "more studies and less discussion and argument are needed" is not heeded by himself, and his speculations often far outrun his data. Several points may be mentioned:

1. Much verbiage is wasted over the distinction between chromosome "coiling" and "twisting," a topic upon which there is little disagreement among cytologists. It is unlikely that the cytologists are quite as naive as the author makes them out.

2. Since relic coiling is not a conspicuous phenomenon in the Protozoa, the author would relegate this term to limbo along with the term interphase, not realizing that the failure to detect relic coiling in his own material is due to the fact that here prophase follows telophase without a break and that an interphase stage with its diffuse chromatin is absent.

3. In speaking of Sparrow's work, the author states that "he [Sparrow] has not shown, nor has anyone else, how relational coiling is produced, how major coils disappear and reappear, and the relation of the ever-present minors to the majors. He has shown majors at metaphase, but he has not shown minors incorporated within them at this or any stage." Sparrow might be flattered with the dubious distinction of having his paper thus singled out as the only one dealing with chromosome coiling worthy of citation, but the cytologists who have contributed critical evidence on these problems will no doubt be somewhat chagrined to find their work so lightly disregarded that it must needs be rediscovered in the Protozoa, and offered as an original contribution.

Notwithstanding the criticisms made, this monograph is still a noteworthy contribution to the literature of chromosome mechanics.

C. P. SWANSON

GÉNÉTIQUE GENÉRALE. *Traité de Zootechnie Générale, Tome I.*

By Marcel Jean-Blain. Vigot Frères, Paris. 200 fr. (paper). xiv + 175 pp. + 21 plates; text ill. 1945.

This is the first of a proposed series of works intended for the student in the field of animal husbandry. Other numbers of the series will cover sex and reproduction, nutrition, influences of external environmental factors, the production of meat, milk, and wool. This initial volume provides a general survey of the science of heredity. As the author clearly points out in the preface, this is not a treatise on genetics but a book designed to provide the necessary background for an intelligent understanding of the mechanics, principles, and influence that heredity assumes as a controlling factor in the development of organisms. With respect to this viewpoint, the book fulfills its purpose. The mechanics of mitosis and meiosis are treated superficially and would not meet the approval of a modern cytogeneticist; but this deficiency is made up by an

excellent discussion of Lamarckian transformism and one on telegony. A clear, comprehensive understanding of these two ideas is of more importance to a practical breeder than a knowledge of the cytomechanics of meiotic synapsis. The usual data and examples included in most elementary texts are also to be found here, the emphasis being naturally on domestic animals whenever possible. There is also a chapter on variation and its statistical treatment, although the latter merely describes methods and short cuts for determining means and standard deviations from a frequency tabulation and gives no application of statistics to genetics problems. There are numerous illustrations and a fairly extensive bibliography.

HENRI C. SEIBERT

DICE OF DESTINY: *An Introduction to Human Heredity and Racial Variations. Second Edition.*

By David C. Rife. Long's College Book Company, Columbus. $2.25. 179 pp.; text ill. 1947.

The second edition of this review of human heredity is not greatly changed from the first, reviewed Q. R. B., 20: 379 (1945). Both the layman and the teacher of genetics will find here interesting information and excellent illustrations. The fundamental laws of heredity are demonstrated by a description of the inheritance of the ability or inability of an individual to taste phenyl-thio-carbamide. There follows, in the second chapter, a discussion of the hereditary basis of the ABO blood groups, MN blood types, the P antigens, and the notorious Rh antigens. In How We Get Our Looks, the author describes hair, eye, and skin color, stature, hair, and head shape, from the point of view of the geneticist. The author treats sex determination and sex-linkage, as well as sex-influenced traits, briefly but adequately. The subject of twins and what they teach the geneticist is considered in some detail. A chapter on dermatoglyphics, with clear and convincing pictures and diagrams, follows. The subject of handedness in relation to speech, twinning, and dermatoglyphics provides most interesting reading. Chapters on the part played by heredity and environment in determining mental ability, special abilities, and personality are excellent. The account of idiot savants will enliven the lectures of any teacher of heredity. A discussion of the race question, both from a biological and social point of view, concludes the book. The appendix includes simple mathematical tests to apply to pedigree charts. A good bibliography for each chapter is also included in the appendix. The reviewer suggests that a chapter on the physical basis of heredity, with illustrations as good as those used by the author in the other chapters of this book, would aid the interested layman.

SARAH B. PIPKIN

BIOMETRICAL GENETICS. *The Study of Continuous Variation.*

By K. Mather. (1) Methuen & Company, London; (2) Dover Publications, New York. (1) 18s. (2) $3.50. (1) x + 162 pp. ill.; (2) x + 158 pp.; ill. 1949.

In the years immediately before and after 1900, two different approaches were made to the problem of heredity. One of these, based upon Mendel's concept of unit characters, dealt with attributes, such as black vs. brown. The other, begun by Galton and Pearson, dealt with metric characters which varied continuously from least to greatest in groups of plants or animals. The concepts necessary for a union of these two approaches, the genetical and the biometrical, were contained in the multiple factor hypothesis of Nilsson-Ehle and East. A modern statement of the theory, including the newer concepts and analytical methods, has been needed for some time. It is effectively supplied in this book by Mather.

In the first two chapters, the author has reviewed the essential features of multifactorial or polygenic systems of inheritance, including the notion that polygenes may be located in both the euchromatic and heterochromatic portions of chromosomes. Differences between polygenes and the major genes of Mendelian genetics are pointed out in detail. The third chapter lays the foundation for the statistical analysis of the inheritance of quantitative characters, with a discussion of the principles and criteria of scaling. Mather has pointed out that dominance or gene interaction or both may appear to be present when one scale of measurement is used, but may disappear when another is used. The choice of a suitable scale is, therefore, one of the major problems to be solved in an investigation of quantitative characters.

The fourth, fifth, and sixth chapters contain an exposition of the steps required in analysing the measurements in order to estimate (1) the fixable variation due to differences in average character expression of the two homozygotes, (2) the unfixable variation due to dominance, (3) the non-heritable variation, (4) the effect, if any, of linkage, and (5) the number of effective factors (where an "effective factor" may be not a single gene but an aggregate of genes in part of a chromosome). The importance of possessing such knowledge lies in its usefulness for predicting (a) the outcome of selection, (b) whether selection toward a specified type is likely to be successful, and (c) whether selection can be accomplished with ease in a few generations or only with difficulty in many generations. The final chapter draws together the discussions of the preceding chapters by stating what information is needed for thorough analyses of cases of polygenic inheritance, and how this information may be obtained by carefully designed experiments.

Familiarity with the concepts of this book is neces-

sary for anyone who proposes to analyse continuously varying characters in plants and animals. The paucity of adequate experiments in the past and the imposing number of quantitative characters yet to be analysed in experimental and domestic animals and plants indicate that this book is most timely.

EARL L. GREEN

CHONDRODYSTROPHIC DWARFS IN DENMARK. *Supplemented with Investigations From Sweden and Norway with Special Reference to the Inheritance of Chondrodystrophy. Opera Ex Domo Biologiae Hereditariae Humanae Universitatis Hafniensis. Volume 3.*

By Ernst Trier Mørch. Ejnar Munksgaard, Copenhagen. Kr. 30.00 (paper). 200 pp.; ill. 1941.

This is an exhaustive study of the occurrence and heredity of chondrodystrophy in Denmark, and is especially remarkable for the fact that in an effort to secure an unbiased picture of the disease the author attempted to examine every chondrodystrophic dwarf alive in Denmark at the time of the investigation. The need for this survey type of approach to the study of various inherited diseases is acute. The material examined included 86 living chondrodystrophics and 22 who were recently deceased. The findings regarding chondrodystrophy are carefully set forth, with emphasis on the criteria for diagnosis and the conditions which must be excluded in a differential diagnosis.

A review of the literature reveals no generally recognized etiological factor except, in an ill-defined fraction of cases, heredity, with general agreement that this is of a dominant type. The author's own material, involving 98 families, included 18 familial and 90 isolated cases. In the familial cases, typical dominant inheritance was observed. The isolated cases were each attributed to a dominant mutation that involved, in all cases, the same gene. While this is very probably so, final proof will rest on an analysis of a considerable body of data comprehending the progeny of isolated cases and the results of marriage of two chondrodystrophics; such data are not now available. If we accept for the present the author's assumptions, the rate of occurrence of the mutation can be calculated, both directly and indirectly. The direct approach employs the fact that of 94,073 children born to normal parents in the Rigshospital, Copenhagen, between 1910 and 1939, 8 were chondrodystrophic, a mutation rate per zygote of 1/11,759 or 0.085%. The indirect approach assumes the number of chondrodystrophics in the population to be at approximate equilibrium. Utilizing his own figures on reproductive efficiency in chondrodystrophy and the birth rate for chondrodystrophy, the author calculates a mutation rate of 0.096%. The correspondence between these two estimates is thought to be satisfactory. An analysis of the data as to possible causes of the mutation revealed that the normal mothers and fathers of chondrodystrophics tended to be older than the normal mothers and fathers of normal children. It was also observed that chondrodystrophics tend to make their appearance as late arrivals among their siblings, but this is thought to be the result of the parental age factor rather than to bear any relation to parity itself. To the reviewer's knowledge, this is the first evidence that mutation rate may vary with parental age in man.

This is an excellent study. A better appreciation of human mutation rates and gene dynamics depends on the appearance of many more investigations comparable to Mørch's.

JAMES V. NEEL

INHERITANCE OF HARELIP AND CLEFT PALATE. *Contribution to the Elucidation of the Etiology of the Congenital Clefts of the Face. Opera Ex Domo Biologiae Hereditariae Humanae Universitatis Hafniensis. Volume 4.*

By Poul Fogh-Andersen. Ejnar Munksgaard, Copenhagen. Kr. 12.00 (paper). 266 pp.; ill. 1942.

The author has undertaken a comprehensive investigation of the occurrence and inheritance of harelip and cleft palate in the population of Denmark. Among 128,306 births in four hospitals in Denmark between 1910 and 1940 there were 193 children with harelip or cleft palate, an incidence of 1/665. This appears to be a significantly higher frequency of harelip and cleft palate than is reported in most other extensive series employing European material. The author has been unable to decide whether the observed difference is merely a matter of more complete ascertainment in the Danish material, or whether the malformation is really more frequent among Danes. The ratio of simple harelip:harelip and cleft palate:cleft palate is very close to 1:2:1. It is felt that the embryological origin and relationship of the three types of defect is obscure. Recent evidence casts doubt on the long accepted view that harelip is due to a failure of fusion of median and lateral nasal processes.

After an extensive review of the literature, the author presents in considerable detail his own genetic material, which consists of studies of the families of 703 propositi. Whereas, as has been frequently observed by others, harelip with or without cleft palate occurs more frequently in males, the author calls attention to the previously unrecognized fact that isolated cleft palate occurs more frequently in females. Figures on familial incidence are different for the two lesions. It is accordingly felt that a genetic distinction must be drawn between these two conditions. On the basis of the family studies, empirical figures are presented for the probability of the appearance of the

disease in children and in sibs of persons who have either harelip with or without cleft palate or who have isolated cleft palate. Approximately 10% of children with harelip or cleft palate have some associated gross malformations, the "normal" incidence of which amongst the newborn is only about 1%. Twin material suggests that considerably less than 50% of the individuals with the requisite genetic constitution actually develop harelip or cleft palate.

The author feels that harelip with or without cleft palate is in most cases due to an irregularly dominant gene the expression of which is partially sex-limited to males, with "considerably less manifestation of the heterozygotes than of the homozygotes, so that the affection is most often of a recessive character." Isolated cleft palate is attributed to an irregularly dominant gene whose expression is partially sex-limited to females. The reviewer feels that insufficient emphasis has been laid on the possibility that both these traits may each have several different genetic bases. It is suggested that when the probability of occurrence of harelip in an unborn child is high, as when the prospective mother and one or more of her children have the condition, this constitutes valid grounds for an induced abortion at the request of the parents.

Fogh-Andersen's monograph is a very significant contribution to the literature on harelip and cleft palate, and a welcome addition to the library of anyone who from time to time is consulted concerning genetic prognosis in this disease.

JAMES V. NEEL

MEDFØDTE DEFEKTER I ØJETS INDRE HINDER. *Klinik og Ætiologi. Arvelighedsforhold. Opera Ex Domo Biologiae Hereditariae Humanae Universitatis Hafniensis. Volume 15.*

By Carl Johan Møllenbach. Arnold Busck and Ejnar Munksgaard, Copenhagen. Kr. 10.00 (paper). 164 pp.; ill. 1947.

The ease with which it is possible to obtain data on hereditary diseases in small, racially rather homogeneous countries such as Denmark is well exemplified by this work. Since it was a Dane, Bartholin, who in 1671 first described a malformation of the iris (coloboma), it seems quite appropriate that another Danish work should describe the present status of uveal defects.

Aside from the clinical study reported in this paper, the principal results of the research have been in determining the incidence and inheritance of aniridia and the various colobomas. As to aniridia, the data have shown it to be transmitted to offspring as a dominant trait. Its incidence in the Danish population is 1 in 95,000. It has been possible to estimate roughly the mutation frequency by enumerating those cases where no previous history of the disease in the family could be demonstrated. This frequency is 1 in 170,000, but the author estimates that the number of cases found is 33% to 50% too low and that the real mutation frequency is 1 in 100,000. The situation with respect to the various colobomas is not quite so clear. Those which are externally recognizable (coloboma iridis) appear to be dominant, but the data are not very convincing. Other colobomas present a partially dominant, partially recessive picture. One gains the impression that the data are insufficient to support the idea that an appreciable fraction of the cases were really hereditary. Coloboma of the macula, at least, does not appear to be so. The author concludes with a survey of the various eugenic laws in Denmark which are applicable to these diseases. It is possible to obtain voluntary sterilization or abortion in these cases. Since some of these congenital defects are quite commonly associated with feeble-mindedness, one cannot agree at times with the advice that "in instances where a pregnant woman with aniridia seeks advice with regard to abortion, one should consider that a childless woman, who wishes a child, is often willing to take a considerable risk of obtaining a defective child in order to have the possibility of getting a normal child, while, on the contrary a woman with several, perhaps defective children, would less often wish to take even a lesser risk of having a defective child; on humanitarian grounds one ought hardly to be completely consistent in giving advice." These seem hardly the grounds for deciding whether the population of blind people in the world ought to be increased.

L. J. MULLINS

GENERAL AND SYSTEMATIC BOTANY

TRAITÉ DE CRYPTOGAMIE. *Second Edition.*

By Louis Lutz. Masson et Cie., Paris. 1450 fr. (paper). 708 pp. + 4 plates; text ill. 1948.

This volume is designed primarily for the use of students of pharmacy, and for this reason, as the author has stated in his introductory remarks, the practical point of view has been maintained throughout. Some 547 of the 673 pages of actual text are devoted to a comprehensive treatment of the fungi alone, the remainder dealing with the lichens, algae, mosses, ferns and fern allies.

After a brief consideration of the fungi as a whole, the morphological and particularly the special physiological features of each of the main classes are adequately dealt with, along classical lines supplemented by time-honored figures drawn primarily from works by European authors. It is the physiological material that lends more than ordinary interest to the volume. Thus, in discussing the species of *Mucor*, considerable data on alcoholic fermentation are given. Some 52

pages are devoted to the physiology of the yeasts including such topics as modern theories of fermentation, growth factors, etc. In the Gymnoascaceae, dermatophytes and important pathogenic species are given detailed treatment. Under the Perisporiaceae, attention is accorded the types of pigments formed and their chemical characteristics. This is followed by sections on nutrition, enzyme production, and practical application of fermentative processes by members of the family.

Certain large groups, such as the Discomycetes and Pyrenomycetes, are passed over briefly, since they offer few organisms of value to the technical mycologist. The same may be said for the Basidiomycetes except for the Hymenomycetes. In the latter group, considerable space is given to the Agaricaceae, and particularly to the genus *Amanita*. Four colored plates are included of the "Amanites mortelles." There then follows an extensive account of the toxicology of fungi. This chapter includes descriptions and drawings of parts and spores of poisonous fungi which should be of value in medico-legal cases that involve mushroom poisoning.

A chapter on the general biology of the higher fungi is followed by a discussion of the Hyphomycetes, including the Actinomycetales. A 27-page account of the fungi pathogenic to man is followed by an informative account of the antibiotic action of fungi.

After short chapters on associations of fungi and higher plants, and on lichens, a 32-page discussion of the algae and their uses is given. The book closes with chapters on bryophytes and pteridophytes which deal mainly with the usual information on their structure and life history.

To sum up, Lutz's book is interesting and useful, at least to the reviewer, mainly for the information brought together on the physiology of the fungi.

F. K. SPARROW

THE GRASSES OF NORTH CAROLINA. *Duke University Publications.*

By H. L. Blomquist. Duke University Press, Durham, N. C. $7.50. viii + 276 pp.; ill. 1948.

In North Carolina 87 genera of grasses are represented, this being more than half the number known for the whole United States, and thirteen tribes, i.e., all but one of those known from this country, and that one represented by a single sparingly introduced species, *Melinis minutiflora* Beauv., molasses grass. Though without the vast grasslands of many western states, North Carolina, extending from a lengthy seaboard to the Southern Appalachians, with the highest mountain east of the Rockies, affords a wide range of soil conditions and altitude, conditions favoring a great variety of plants. A map shows the extent of the coastal plain, the piedmont, and the mountains. The discussion of the ecology and the distribution of the grasses, given in the Introduction, is especially interesting and is illustrated by thirteen excellent photographs, which show an extensive cordgrass saltmarsh, (representative of such land-building from the Gulf of St. Lawrence south), sand-binding grasses of the coast, canebrakes, savannas, forested areas, and the "bald" (almost pure grassland) on Roan Mountain. Pastures, meadows, lawns, and soil conservation are briefly discussed. The structure of the grass plant is described and the flowering parts figured. Keys to tribes and genera, with descriptions and ranges of distribution, comprise the principal part of the work. The species are each illustrated by figures of habit, inflorescence, or at least a spikelet of each, all illustrations having been drawn for this work. The names of the illustrators are not given (a few drawings are signed but so minutely as to be almost illegible). In the Preface, however, it is stated that aid was "obtained through the National Youth Administration." Presumably the figures were made by students, who, from the accuracy of the drawings, must have had constant guidance. An unpublished by-product, too, must have been a group of graduates with a detailed knowledge of grasses. Numerous helpful notes by the author show what a close study was devoted to these grasses over a long period. Current synonymy and common names are given, and a glossary is provided. A series of dotted maps shows distributions by counties. This part of the work has been criticized because published records are not represented by dots; but dots on a map should refer to evidence preserved in the herbarium, where it is available for examination. Records, even by distinguished botanists, are hearsay evidence until they have been verified by an examination of the specimens on which the reports were based. In an Appendix there is a key to the more common grasses without inflorescence, with illustration of their vegetative characters. Since the flowering period of most grasses is usually short, such a key is very helpful. In all, there are 249 line drawings and photographs, besides a frontispiece showing a herd of fine cattle in a good meadow, with the legend: "All flesh is grass." The book is well printed, the photographs especially so.

AGNES CHASE

AMERICAN WILD FLOWERS. *The New Illustrated Naturalist.*

By Harold N. Moldenke. D. Van Nostrand Company, Toronto, New York, and London. $6.95. xxvi + 453 pp. + 64 plates; text ill. 1949.

The author has set himself the task of writing a popular, well illustrated book of the more showy wild flowers of this country with a minimum of the technical and

somewhat stifling jargon of the professional botanist. His audience is the traveller who wishes to know, but not as intimately as the botanist, the plants that meet his eye and excite his curiosity. To write such a book is by no means an easy task, for it requires a wide botanical knowledge, a feeling for plants unclouded by a mawkishly sentimental attitude, a sense of narrative and proportion, and an eye for illustrative details. The volume speaks for itself, for it is ably done. Authoritative enough in treatment for the botanist, on the other hand its light and familiar style, well spiced with botanical lore, commends it to the nature lover. The reader will have difficulty running down an unknown flower which is not illustrated, for no keys are provided. He may also find some cause for annoyance in the fact that text and illustration rarely go hand-in-hand. These, however, are minor flaws, readily forgiven.

C. P. SWANSON

ECONOMIC BOTANY

THE PLANT IN HEALTH AND DISEASE. *Agricultural and Horticultural Series.*

By W. A. R. Dillon Weston and R. Eric Taylor; with Foreword by J. A. Scott Watson. Crosby Lockwood & Son, London. 21s. xii + 173 pp. + 61 plates; text ill. 1948.

Books on plant pathology have been distressingly alike in basic structure: first, diseases caused by phycomycetes; second, diseases caused by ascomycetes. Truly, Pasteur exerted a powerful influence on the thought of people concerned with disease: "Cherchez la fungus." The English have faced this situation directly. They label themselves applied mycologists. Americans have chosen a title for what they would be, plant pathologists, but they have been mostly mycologists, too.

Here is a book on plant pathology that considers the matter from the plant's eye view—not the fungus' eye view. By and large, the authors have handled the subject well. They retrogress in a few instances, however. They have one chapter on Virus Diseases; and they hold that boron deficiency is not a true disease. Apparently, they would hold that a Chinaman with beri-beri is not sick either, simply because no other organism is involved.

This is a book aimed at the English "Advisory Officer" and the American "Extension Plant Pathologist." Whether every plant pathologist buys a copy or not, he should certainly peruse it for a refreshingly new viewpoint on the presentation of his field.

J. H. HORSFALL

COMMON BRITISH GRASSES AND LEGUMES. *Second Edition.*

By J. O. Thomas and L. J. Davies. Longmans, Green and Company, New York, London and Toronto. $2.20; 9s. viii + 120 pp.; ill. 1946.

This work is intended as an introduction and guide for the British agricultural student and farmer to their commoner forage plants. The structure of the floral and vegetative organs of grasses is first explained and illustrated, and germination and growth habits are described, with explanatory figures. Although there are more than one hundred British grasses, only the most important of them, 28 in number, are included here, with discussions of those characters which render them valuable—their productivity, persistence, palatability, winter greenness, and the like. A key to 30 genera of grasses (two not having been included in the selected 28) based on vegetative characters is given. This key should prove most helpful, since grasses are in flower but a relatively short time. Botanical descriptions and illustrations of the 28 species follow (in alphabetic order), with notes on their economic value. The figures as a whole are helpful, but some, particularly those of the panicles and spikelets of the species of *Poa*, are scarcely representative of them. The fifteen legumes included are treated in like manner to the grasses, with detailed descriptions of their floral and vegetative characters and germination, with illustrations, and a key to the species. Botanical descriptions and economic notes are given for each, as well as for an additional forage plant in the Rosaceae which commonly grows with one of the legumes. Throughout the work the descriptions are so arranged that they are readily comparable, which is a great convenience, especially to beginners. Since people in general so commonly think of "grass" as the green covering of meadows and pastures, without distinguishing true grasses from clovers and like plants, and much less distinguishing between different kinds of grasses, such works as this, presented in simple language and well illustrated, are important.

AGNES CHASE

GENERAL AND SYSTEMATIC ZOOLOGY

ESSENTIALS OF ZOOLOGY. *Emphasizing Principles of Animal Biology. Second Edition.*

By George Edwin Potter. The C. V. Mosby Company, St. Louis. $4.00. 544 pp.; ill. 1948.

In addition to the correction of errors, the second edition of this very well balanced textbook (cf. Q. R. B. 16: 226. 1940) contains minor revisions and editions of material. Tables of digestive enzymes, vitamins, and types of blood cells, and also a section on the snail are new. The latter represents a particularly worthy aim

to use familiar and locally abundant animals for zoological study. It is surprising what a large proportion of our standard zoology training is still based on choices of animals made by T. H. Huxley or Louis Agassiz, and exhibits a European rather than American assortment of types.

BENTLEY GLASS

LABORATORY DIRECTIONS IN GENERAL ZOÖLOGY. *Fourth Edition.*

By Winterton C. Curtis and Mary J. Guthrie. John Wiley & Sons, New York; Chapman & Hall, London. $2.00 (paper). viii + 236 pp.; ill. 1948.

This is a fourth edition of a laboratory guide to accompany the authors' well-known textbook of zoology. Several alterations have been made and certain trouble spots have been eliminated as a result of many years' use. One interesting innovation has been added: a human genetics chart which the student can fill in from personal information. Emphasis is placed on the presentation of principles rather than of animal types representing the major phyla. As a result, function is stressed as much as form. The initial part of the guide starts with a comprehensive survey of the frog, in the belief that beginning students are better acquainted with vertebrate than with invertebrate structure. This survey of the frog includes its anatomy, physiology, histology, reproduction, and development. Heredity and variation in *Drosophila* and man follow. The remainder of the guide is concerned with the invertebrate phyla and ends with a survey and classification of the animal kingdom, the latter leaning heavily on the scheme proposed by Hyman. An appendix provides supplementary directions for experiments and for the preparation of stains and reagents. Directions are explicit, and drawings help to interpret details that the student would otherwise miss from his own dissections.

HENRI C. SEIBERT

LABORATORY GUIDE IN ANIMAL BIOLOGY. *Second Edition. McGraw-Hill Publications In The Zoological Sciences.*

By Robert H. Wolcott and Eugene F. Powell. McGraw-Hill Book Company, New York, Toronto, and London. $1.50. x + 113 pp.; ill. 1948.

The second edition of this laboratory guide, in contrast to the previous one, follows the type method, since the authors (the junior author completed the first edition and has made the corrections and other changes in this new edition) believe that a knowledge of structure is necessary for a good understanding of zoology. Therefore the guide begins with preliminary laboratory instructions, the use of the microscope, the study of cells, proceeds with ameba, paramecium, volvox, mitosis, tissues, oogenesis, and embryogeny. Examples from each of the major phyla are then taken up in sequence. For those animals which can be easily obtained alive, additional instructions are included for simple experiments on behavior.

HENRI C. SEIBERT

THE SPIDERS OF HISPANIOLA. *Bulletin of the Museum of Comparative Zoölogy at Harvard College, Volume 100, Number 4.*

By Elizabeth B. Bryant. Museum of Comparative Zoölogy at Harvard College, Cambridge. $2.00 (paper). Pp. 331–447 + 12 plates. 1948.

In this fine work the author has included 120 species of spiders, of which 59 are new to science. The latter, and some of the others, are described and illustrated. Although not all of the descriptions are detailed, in all cases salient features have been selected for mention, and these, together with the neat and clear illustrations, are sufficient for identification even though there are no keys. Some bionomic notes are included. The remaining species are merely listed with localities.

There are four new genera based upon new species and not upon revisionary studies of existing genera. In the case of one new genus, *Lomaita*, placement to family could not be made with certainty partly because of the author's belief that all members of the Linyphiinae (= Linyphiidae sens. str.) have stridulating ridges on the chelicerae. The usefulness of this character may be questioned, since there are many typical members of this family in which these structures are quite inconspicuous or lacking altogether.

The taxonomic arrangement is patterned after the *Systema Aranearum* published by Petrunkevitch in 1928, and the spiders are found to belong to 26 families as then understood. Although not all araneologists use this arrangement at present, none would have any difficulty adapting it to his own concepts.

Two families, the Argiopidae and Salticidae, are not included, the author having previously published on each of them separately. However, they are commented upon in making comparisons with the spiders known from other islands of the West Indies which have likewise engaged the attention of the author. Students interested in the West Indian fauna will find very useful the table of statistics for species from Cuba, Puerto Rico, St. Vincent, Virgin Islands, and Hispaniola.

B. J. KASTON

THE SALTICIDAE (SPIDERS) OF PANAMA. *Bulletin of the Museum of Comparative Zoölogy at Harvard College, Volume 97.*

By Arthur M. Chickering. Museum of Comparative Zoölogy at Harvard College, Cambridge. $4.50 (paper). 474 pp.; ill. 1946.

This impressive monograph is the seventh, and largest, of a series of papers dealing with the spider fauna of Panama. The first appeared in 1937, and each has treated a different family. The present one deals with the jumping spiders.

The work is entirely of a taxonomic nature, and the greater part of the material considered was collected by the author himself. There are detailed descriptions of eighty-one new species, and over a hundred others are commented on, briefly for the most part. Fourteen new genera have been established, based on the new material. There are analytical keys to genera and in many cases to species, but unfortunately their usefulness is limited. For example, in the key to the genera of Lyssomaninae we are asked to choose between "small and very slender spiders with long slender legs" and "larger and much more robust spiders with moderately robust legs." For one unfamiliar with the genera *Chinoscopus* and *Lyssomanes* this would be a difficult decision to make, especially if one were trying to take a single individual through the key. To add to the difficulty, the information supplied in the description of *Chinoscopus* does not include any dimensions. Again, in distinguishing two species of *Cobanus* we are asked to choose between "epigynal plate almost exactly two thirds as long as wide, completely divided" and "epigynal plate wider than long in ratio of 3:2, completely divided." Probably four-fifths of the couplets consist of several lines of description, against which is set the alternative "not with the combination of characters given above." It would seem that to employ pairs of contrasting characters would result in keys of easier workability.

However, in cases where the keys present difficulties, there is no doubt that the serious student of tropical spiders will be able to identify his material on the basis of the good, clear illustrations (made by the author), of which there are 432, and the very full descriptions. It is obvious that a great deal of time and energy were spent in producing this large contribution to American araneology.

B. J. KASTON

LA VIE DES SAUTERELLES. *Histoires Naturelles—6.*

By L. Chopard. Gallimard, Paris. 150 fr. (paper). 204 pp. + 18 plates; text ill. 1945.

Lucien Chopard, one of the world's leading authorities on the taxonomy and biology of the Orthoptera, has presented here a very readable account of the grasshoppers and their allies. The Orthoptera are an extremely varied lot, but the majority of them occur in the tropics. Relatively few of them inhabit temperate regions, and as a result they attract relatively little attention in comparison with the much commoner butterflies, moths, and beetles. To remedy this situation, Chopard gives a popular account of the different types of grasshoppers, crickets, cockroaches, and their kin, and then describes the great variety of forms which they assume in the various regions and ecological niches. A chapter is devoted to their songs and its significance; another to the development from the egg to the adult of the various forms; and two more to the biology of the different types. The final chapter is a discussion of the domiciliary, destructive, and useful forms. In his treatment of the last category, Chopard mentions how many of these insects have been useful as media to the morphologist, the physiologist, and the geneticist. The book is printed satisfactorily but on a poor grade of pulp paper, with fifteen clear line-drawings as text figures and eighteen excellent plates on coated stock. Many more works of this type are needed, particularly in English, to acquaint the general public, and the scientist as well, with the fascinating world of the insects.

ROBERT MATHESON

COLEOPTERA: HALIPLIDAE, DYTISCIDAE, GYRINIDAE, HYDROPHILIDAE, LIMNEBIIDAE. *Contributions toward a Knowledge of the Insect Fauna of Lower California, Number Eleven. Proceedings of the California Academy of Sciences, Fourth Series, Volume XXIV, Number 11. June 11, 1948.*

By Hugh B. Leech. California Academy of Sciences, San Francisco. $2.50 (paper). Pp. 375–484; ill. 1948.

This is a well executed, illustrated treatise on the water beetles (Hydradephaga and Palpicornia) of Lower California. Forty-five genera and ninety-five species, four of which are new, are recorded from the peninsula. The author has endeavoured to analyse the origin and relationships of these beetles, with the following results: at least ten are thought to be endemic to Lower California; the Vancouver fauna is represented by five to seven species; the Californian by at least fifteen; the Sonoran by about fifteen; and the Neotropical by ten. The main body of the work is devoted to a careful taxonomic treatment of all the forms which occur in the peninsula. Keys to both genera and species are given. At the end is a check list of all genera and species of aquatic Coleoptera (exclusive of the Dryopidae and Elmidae) now known to occur in Lower California.

ROBERT MATHESON

AUS DEM LEBEN DER BIENEN. *Fourth Edition.*
By K. v. Frisch. Springer-Verlag, Wien. $2.00 (paper). vi + 196 pp.; ill. 1948.
DUFTGELENKTE BIENEN IM DIENSTE DER LANDWIRTSCHAFT UND IMKEREI.
By K. v. Frisch. Springer-Verlag, Wien. $3.70 (paper). x + 189 pp.; ill. 1947.

In these two volumes Karl von Frisch has presented to the reading public the story of the honey bee in as complete a form as scientific investigation to date has made possible. The first work was intended to present a comprehensive picture of bee life in a readable manner. To this end the data, proofs, and documentation essential to a scientific treatise have been omitted. For the same reason, practical information of interest chiefly to apiculturists has also been omitted. Since the appearance of the original volume in 1927, considerable advances have been made in our knowledge of the physiology and habits of the bee, largely through the efforts of von Frisch himself. All of this new information has been included in this fourth edition. To those who are familiar with the author's research papers in various scientific journals, this compact little volume will be welcome as a concise summary of those investigations. To the general reader, who has found pleasure and interest in Maeterlinck's *The Life of the Bee*, this work will come as a fascinating complement which points the way to answers to many of the riddles of bee behavior. This account is more factual than former essays on the subject and devoid of much of the philosophical musings of its predecessors. Here one finds a straight-forward story that begins with a brief introduction to the castes of bees, a description of the hive, construction of the comb, feeding habits, and collection of nectar and pollen. Here too are accounts of the bee's senses, of the fabulous dances by which foraging bees convey to their nest-mates information that enables them to locate nectar in the field, of homing, and of insect societies.

The second volume, entitled *Odor-Guided Bees in the Service of Agriculture and Apiculture*, deals with the relation of the olfactory sense of bees to their behavior in the field and to honey production. Von Frisch describes the laboratory conditioning experiments which led him to the idea of training foraging insects to collect nectar from one species of plant to the exclusion of others. Briefly, bees are given an opportunity to drink sugar water placed in close proximity to a selected odor. These bees then confine their searches in the field to plants emanating that scent. Other worker bees in the hive are likewise directed to the same flowers. This technique of odor training opens the way to the production of honey of specified quality. Also, the pollination of specific crop plants can thus be directed. Much of the information concerning the sense organs and behavior which was presented in the first volume is repeated here, by way of introduction to the main discussion.

This little volume, written for the agriculturist and the beekeeper, is a beautiful illustration of the application of so-called "pure" research to economic problems. It illustrates forcefully how basic research may serve as an excellent handmaiden to applied science.

V. G. DETHIER

CLASSIFICATION OF FISHES BOTH RECENT AND FOSSIL. *Travaux de l'Institut Zoologique de l'Academie des Sciences de l'URSS. Tome V, Livr. 2.*
By Leo S. Berg. [Moscow and Leningrad]; J. W. Edwards, Ann Arbor. $7.00. vi + pp. 87-517; ill. [1940]; 1947.

Berg's volume gives the first comprehensive classification of fishes to appear since that of Jordan in 1923 and Tate Regan in 1929. It is invaluable both to the specialist and the general biological world, since it has incorporated the more recent work on the systematics of living fishes and the basic studies done on Paleozoic fossil types during the two decades preceding. The classification was originally published by the Russian Academy of Sciences in 1940. Few copies, however, reached this country, and we are indebted to the ichthyologists of the University of Michigan for making it generally available through this lithoprinted edition. The text is in both Russian and English; for since the illustrations are incorporated in the Russian text, reprinting the full book was a necessity.

The classification carries downward to families, with generally comprehensive diagnoses of major groups, but with family definitions brief or absent. Geographical and geological distributions are given for families. No attempt is made to list genera, although occasional mention is made of common or interesting types. For orders, suborders, and superfamilies Berg discards many of the usual names and adopts a nomenclature in which the endings -formes, -oidei and -oidae, respectively, are added to the stems of the names of representative families. This has the advantage of simplification, and of making the learning of about 20 teleost group names unnecessary for the neophyte. The reviewer, however, sees little to be gained by replacing such familiar terms as Apodes and Ostariophysi by Anguilliformes and Cypriniformes. In general, Berg follows the almost universal tendency of taxonomists continually to increase the systematic status of groups, and as a result the fishes are here divided into no less than twelve classes and 114 orders.

The author solves the problem of the position of the lower chordates by erecting a Phylum Vertebrata from which the urochordates and hemichordates are cast into outer darkness. *Amphioxus* is included in a Subphylum Acrania opposed to all other vertebrates—

Subphylum Craniata. A second major dichotomy consists of sharply separating the Agnatha as a superclass from all other forms—a violent cleavage which seems unnecessary to the reviewer. Under the Gnathostomata the jawed fishes are considered as a Series Pisces.

The elevation of the Agnatha to a superclass allows Berg plenty of room to subdivide the ostracoderms and cyclostomes, which he does freely, spreading them out into half a dozen classes and 14 orders. The resulting system frequently appears to make too great distinctions between obviously related types. Thus, for example, *Trematas pis* is placed in an order distinct from the more typical cephalaspids, with no stated reason other than the subdivision of the "electric fields"—hardly a feature of ordinal value.

Above the ostracoderm level, current practice tends to group the jawed fishes into not more than three classes. Berg has seven. The reviewer and many others have accepted Watson's thesis that the varied "lower" jawed fishes of the Paleozoic may be reasonably grouped in a single class (which he termed the Aphetohyoidea, but for which the older and simpler term Placodermi is available). Berg splits this group into three: most, including the arthrodires and various curious rhenanids or stegoselachians, are put in his Class Coccostei, but the acanthodians and antiarchs are placed in separate classes. Considerable justification can be found for regarding the acanthodians as distinct, since in the present state of our knowledge we have little to tie them to the arthrodire stem; but on the other hand, modern work tends to show that the antiarchs are intimately bound to the arthrodires.

Instead of following general current usage in considering the shark-skate group and the chimaeras as forming jointly the Class Chondrichthyes, Berg makes the Holocephali and Elasmobranchii separate classes. This procedure is not without considerable justification, for the absence of a bony skeleton in the two groups is a degenerate feature which may well be due to parallelism, and there is little of a positive nature to unite them. The ancestry of the two is still obscure, and sharks and chimaeras may well have evolved independently from the placoderms. It may be noted, incidentally, that despite his general tendency to effect oversharp separations between related types, Berg includes without question all of the varied and often problematical bradyodonts in a common order with the living chimaeras.

Among the bony fishes, the Dipnoi are here made a class separated from the crossopterygians plus actinopterygians, which together constitute the Class Teleostomi. This mode of treatment dates from the earlier years of the century, when the distinctive features of the modern lungfish seemed to be indicative of an archaic nature and remoteness from other bony fishes. The work of the last quarter century has, however, shown that this is illusory, that lungfishes and crossopterygians are really closely allied, and that the primary division of the Osteichthyes should be into dipnoans plus crossopterygians on the one hand, and actinopterygians on the other.

Among the actinopterygians, Berg discards the old terms Chondrostei, Holostei, and Teleostei as meaningless, since it is probable that there has been considerable parallelism in the evolution of "higher" from "lower" ray-finned forms. It is undoubtedly true that such parallelism has occurred. Nevertheless, in default of a more definite knowledge of phylogeny, use of the older terms enables one to assemble the components of this enormous group in some sort of comprehensible fashion. Berg simply lists, seriatim, some 60 orders of actinopterygians, without the slightest indication, except for position in the list, that the Order Redfieldiiformes (for example) is any more closely related to the Order Perleidiformes than to the wildest of modern teleosts. Even so, his serial arrangement enables one to reconstruct within his framework the familiar major groups. The first 13 in his list of actinopterygian orders make up the chondrostean assemblage; the next 6 (Amiiformes to Pholidophoriformes), the Holostei; the final 41 are the teleostean orders.

His arrangement of the teleosts conforms in considerable measure with current practice. Here, as elsewhere, Berg often tends to regard some particular feature of a striking type as being important enough to remove it completely from the group in which its general organization appears to place it. Thus the galaxiids, which seem in most regards to be closely related to the salmons, are removed not only from the Salmonoidei but from the whole isospondyl order (Berg's Clupeiformes) and are placed in a separate order, with no stated reason other than an unusual position of their olfactory bulbs; *Mormyrus* and *Gymnarchus* are placed in an independent order simply because of their oversized cerebellum.

For the most part this discussion of Berg's book has been devoted to major points in classification in which his arrangement might be reasonably disputed. These differences, however, have not been meant to reflect in any way on the great value of his work. It is an important modern synopsis of fishes, and should be at the hand of every worker in ichthyology and related fields.

ALFRED S. ROMER

FISHES OF THE WESTERN NORTH ATLANTIC. *Part One. Lancelets, Cyclostomes and Sharks. Memoir Sears Foundation for Marine Research, Number 1.*

Edited by John Tee-Van, Charles M. Breder, Samuel F. Hildebrand, Albert E. Parr and William C. Schroe-

der. Sears Foundation for Marine Research, Yale University, New Haven. $10.00. xviii + 576 pp.; ill. 1948.

More than ten years have passed since the plan to monograph the fishes of the Western North Atlantic was actually put into operation. This plan was conceived at New Haven, and with the establishment of the Sears Foundation for Marine Research at Yale University funds for the project were made available. It was realized that to complete such a revisionary descriptive monograph on the scale which was envisioned and in a reasonable length of time would require the cooperation and assistance of many ichthyologists, with some means of coordinating the plans and methods of handling the material, so that the separate completed volumes would be reasonably uniform. Hence an Editorial Board was formed, and an Advisory Committee was selected to draw up a detailed outline and set of instructions for the preparation of manuscripts. The text was not to be purely technical descriptive taxonomy but of a more general nature, bringing together and synthesizing all our knowledge of the fish fauna of this region, for use by the general zoologist, ichthyologist, amateur naturalist, sportsman, and commercial fisherman.

This volume, covering the lancelets, cyclostomes, and sharks, is the first of the series, which is expected to run to six volumes. In reviewing a general revisionary treatise of this scope, it is scarcely possible to comment on the details, the ultimate value of the descriptions, and the nomenclature used (the point of view of the latter has been conservative). It seems more worth-while to discuss the manner of presentation and the way in which the tremendous amount of material has been covered.

The area defined as the Western North Atlantic embraces the western half of the North Atlantic, with adjoining gulfs and seas from Hudson Bay south to the Amazon River. Two clear maps show the region and indicate many of the more important localities. Shore and oceanic species are treated in full, bathypelagic ones in keys only. Cosmopolitan species, of course, have been included; species living close to outer borders are described in addenda. Closely related species are covered in discussion or footnotes, whereas extralimital genera are included in the keys. By this treatment the scope has been considerably broadened and the value of the monograph as a reference for other areas as well has been greatly increased.

Classes and orders are defined by characters, and their relationships to other classes, orders, and suborders have been discussed. The orders have been treated rather fully, with discussion not only of their characters and relationships, but also of the size, breeding habits and development, intelligence and senses, luminescence, food, number of species, danger to man, commercial importance, habits, and range. Genera are listed with synonyms, characters, ranges, and fossil forms, while species accounts occupy most of the pages, covering with some detail the distinctive characters, descriptions of ♂ and ♀, color, size, developmental stages, habits, relation to man, range, occurrence in the western North Atlantic, synonyms, and references. Altogether 67 species (6 lancelets, 2 cyclostomes, and 59 sharks) are discussed in detail, three of the sharks being included as addenda because of their living close to the southern borders (2 from Uruguay and Brazil; one from Northern Argentina).

The keys are of simple outline type, using alternative characters. These characters are usually few and deal with external features and proportions. Sometimes the characters are rather general and relative and, if the user has only one specimen at hand, are likely to be not entirely satisfactory. The references are exceedingly numerous and are listed under synonyms, including common names and with brief annotations. Except when noted, the authors have consulted the original. This alone represents a tremendous amount of work and time, and would have been a major contribution in itself. To facilitate use, references for cosmopolitan species are divided according to geographic area.

The figures are all uniform, neat, clear drawings of the entire animal and with inset drawings of details of nostrils, eye denticles, teeth, developmental stages, and other useful diagnostic features to aid in clarifying the keys or descriptive characters. There are separate indices for common and scientific names. In view of the anticipated use of the volume by persons not familiar with scientific names this is perhaps desirable, but since many of the common names are merely anglicized forms of the scientific names and only five pages have been added to the twenty-four page index of scientific names, the advantages gained by this separation are not evident. The edition has been limited to 2500 copies printed on 50 per cent rag text paper. Pages are 9 x 12 inches with wide margins. The makeup and binding are excellent.

There is little about the book to criticize and much to praise: the authors for their careful and painstaking examination and recording of most of the available specimens and references in various museums and libraries, and the editors for the few typographical errors and excellent makeup. All have done an obviously great amount of work to make this a contribution as nearly perfect and complete as the present state of knowledge allows.

LOREN P. WOODS

THE FLIGHT OF BIRDS. *Analyzed Through Slow-motion Photography. Bulletin Number 28.*

By John H. Storer. Cranbrook Institute of Science, Bloomfield Hills, Michigan. $2.50. xvi + 94 pp.; ill. 1948.

The use of fast action movie cameras has made it possible to obtain pictorial records of birds in flight that provide a permanent record for detailed study and analysis. Utilizing this technique, the author has crammed into his little book a considerable amount of information that goes far to explain the aerodynamics of bird flight. The science of aerodynamics involves considerable physics and mathematics, yet Storer has explained the general principles involved in only 10 pages, and in such a way that they can be understood by any literate person. A comparison is then made between the equipment of a flying bird and that of an aeroplane. How ideally adapted the construction of a bird wing is for its function is ably demonstrated. The outer half of the wing acts as propeller, the primaries being capable of twisting to correspond to the change in pitch of a propeller blade. Since the wing only goes through a half circle and must return to its starting position, these feathers must also be capable of reversing their pitch, a fact that is brought out by the pictures. The morphological details that provide this movement are explained. The inner half of the wing provides the lift and supports the bird in flight throughout the entire wing beat, the angle of attack being constantly adjusted to compensate for the up and down motion.

A large chapter entitled flight comprises most of the book. In it are analysed the mechanisms of actual flying, the motion of the wing being analysed in detail during its entire cycle. The motions involved in take-off and in landing, in soaring, gliding, and the use of air currents, in backward flight, and in diving are discussed, along with maneuverability and speed. The problems of wing loading vs. size of wing, speed, and habits of the bird conclude the textual material. Accompanying all of these topics are photographs, most of them serially arranged, that illustrate the mechanisms employed by the bird. At all times comparison is made to the aeroplane.

The major weakness of this book is its brevity. Not that brevity is a fault. Still, some discussions could have been made more lucid, and others have been expanded, so that this book would have been the ultimate reference on its subject. Also, some of the illustrations seem to have suffered by reason of poor reproduction. Nonetheless, this is a remarkable contribution considering its 94 pages, index included. Every student of birds should read it.

HENRI C. SEIBERT

BIG CATS. *Kings of the Jungle in Fact and Fiction. Edited by Frances Brentano; with an introduction by W. Adolphe Roberts. Ziff-Davis Publishing Company, Chicago and New York.* $3.50. xiv + 306 pp. 1949.

A collection of short stories about big cats: tigers, lions, leopards, jaguars, and others of the group. The stories are all popular in nature and contain little information of interest to the biologist. They are selected from a wide variety of sources and center around hunting and circus tales. As stories they vary from exciting to dull. Their authenticity and accuracy shows a similar wide range of variation. The reviewer was on the whole not particularly impressed with the collection.

JOHN CUSHING

WILD WORLD TALES. *The Tale of the Mouse, the Moth and the Crow. Fourth Edition. By Henry B. Kane. Alfred A. Knopf, New York.* $2.75. xii + 131 pp.; ill. 1949.

A clever children's book telling the stories of a mouse, a moth, and a crow in a manner that should appeal to children. Each page of the story is accompanied by an excellent photograph pertinent to the story and also by a line drawing. This book is recommended to parents and teachers who may wish to arouse an interest in nature in their children.

JOHN CUSHING

ECONOMIC ZOOLOGY

INSECT PESTS OF GLASSHOUSE CROPS. *Agricultural and Horticultural Series. Second Edition. By Herbert W. Miles and Mary Miles; With a Foreword by John Fryer. Crosby Lockwood & Son, London.* 15s. 200 pp. + 24 plates; text ill. 1948.

This second edition has been somewhat enlarged, a few new illustrations added, and the arrangement somewhat changed. The book consists of nine chapters, each chapter, except the first two, dealing with various phases of the insect pests usually found associated with greenhouse culture. These are: general soil pests; caterpillars and leaf miners; aphids, capsids, and leaf-hoppers; white fly, scale insects, and mealy bugs; thrips and spider mites; eelworm pests; and last, miscellaneous pests. The first two chapters discuss the general conditions found in glasshouses and the methods of pest control that have been developed to meet such conditions.

The book is especially valuable for its detailed life histories of the various pests. Most of the insects are well illustrated (92 halftones) and carefully described. The methods of control utilize the standard insecticides which have been in use for a number of years. Mention is made of the newer synthetic insecticides and the methods of applying them, but the authors advise care in their use and reliance upon the official scheme for proprietary insecticides for guidance. Practically

no mention is made of the many recent advances in the control of greenhouse pests made in the United States. There is a fair list of references in an appendix, and there is an excellent index.

ROBERT MATHESON

WILDLIFE MANAGEMENT. *Upland Game and General Principles. The American Forestry Series.*

By Reuben Edwin Trippensee. McGraw-Hill Book Company, New York, Toronto, and London. $5.00. x + 479 pp.; ill. 1948.

Not since 1933, when Leopold's *Game Management* first appeared, has anyone attempted to write a textbook on wildlife management. In the succeeding span of fifteen years, many advances in knowledge and technique have been made, and this field of zoology, which has been aptly called applied ecology, now has its specialists, societies, and publications like any full-fledged discipline. It should be brought out to start with that the title of this book is somewhat misleading, since it concerns only upland game and does not include fish or waterfowl.

The 31 chapters are grouped under five main categories: farm wildlife (rabbit, Hungarian partridge, pheasant, bobwhite, tree squirrels); forest wildlife (black bear, deer, prairie chicken [sic], ruffed grouse, varying hare, wild turkey, woodcock); wilderness wildlife (elk, bighorn sheep, wolf, grizzly bear, moose, antelope, mountain goat, caribou); miscellaneous wildlife relationships (variations in numbers, predator-prey, game production and harvest, refuges, winter feeding); and wildlife administration (administration, training, and policy). Each of the first three sections has an introductory chapter on general problems and management procedures applicable to each of the three different types of areas here recognized. This general chapter is then followed by separate chapters for each of the game species. In the latter the material covers the distribution, life history and ecology, food, population, mortality, and management of the species. There is a bibliography at the end of each chapter.

This arrangement differs from that in Leopold's book by discussing management species by species, rather than by principles irrespective of the species concerned. Consequently, the two books for the most part complement rather than supplement each other.

Because of these two different methods of approach it is difficult to evaluate the advances that have been made in this field during the intervening years. Certainly knowledge of the details of life history has been increased, and the techniques of censusing, marking, and general field work have improved. On some of the major problems, however, little advance seems to have been made. Thus the cyclic population fluctuations are not much better understood now than 15 years ago, nor is the problem of the predator-prey relationship solved to everyone's satisfaction. Perhaps this reflects a tendency on the part of Federal and State agencies to desire immediate, visible results. This is only natural, since wildlife work is beset with exasperating political angles, but to arrive at a true scientific basis for management procedures, instead of the hit-or-miss methods that are so frequently employed, funds and time will have to be allocated to pure research. One phase of the subject that has progressed to a considerable extent and that is not sufficiently emphasized in the text is the improvement in the public relationships with the landowner.

Farm and forest wildlife are well presented in the book, and the material includes those recommended practices employed by the majority of field workers. On the other hand, wilderness wildlife is rather sketchily described, this section leaving the reader with the impression that next to nothing is known concerning the big game animals. It is true that reliable data for big game animals are deficient, compared to those for rabbits or squirrels, but more is known about big game animals than is considered here. This defect is to be regretted, inasmuch as many of the larger game animals are the source of continual argument between landowners and stock-raisers on the one hand, and hunters and conservationists on the other. As a consequence of the incessant ballyhoo, many of the true facts have been misrepresented.

The Preface of the book indicates that this volume is only Part One of a larger work. Part Two, on fur bearers, waterfowl, and game fish will be published separately. It is to be hoped that the companion volume will appear shortly, so that this valuable start on a young, but rather difficult, branch of applied zoology may be completed.

HENRI C. SEIBERT

UPLAND GAME MANAGEMENT.

By Floyd A. Johnson. Wildlife Management Institute, Washington, D. C. 21 cents (paper). 80 pp.; ill. 1948.

WATERFOWL MANAGEMENT ON SMALL AREAS. *Part I. Ponds and Marshes for Waterfowl. Part II. Methods of Pond and Lake Construction.*

By (I) C. E. Addy; (II) L. G. MacNamara. Wildlife Management Institute, Washington, D. C. 21 cents (paper). 84 pp.; ill. 1948.

These two useful pamphlets are designed for the layman who is interested in developing upland game or waterfowl on his own property. Properly stressed is the fact that good land management goes hand in hand with wildlife abundance and that both are a reflection of good farming principles. Practical suggestions are given for ways and means of providing cover and food for the upland game and for the construction of artificial ponds, dikes, and water control

structures for the waterfowl. Lists of good plant foods are included. Photographs and drawings of proper management techniques and their beneficial results are liberally supplied.

HENRI C. SEIBERT

A GUIDE TO MARKETABLE FISH.

By R. J. Daniel. Published by the Author, Department of Oceanography, The University, Liverpool. 3s. (paper). 68 pp.; ill. [No date].

This booklet includes short sections on the pathology, parasitology, and preservation of the principal commercial fishes of western European waters, as well as diagnostic drawings and comparative tables.

A REPORT UPON THE GRAND COULEE FISH-MAINTENANCE PROJECT 1939–1947. *Special Scientific Report Number 55.*

By Frederic F. Fish and Mitchell G. Hanavan. United States Department of the Interior, Fish and Wildlife Service, Washington, D. C. Paper. iv + 63 pp.; ill. 1948.

Can this in truth be the record of one of the greatest experiments in practical biology in our generation? Is this the official word on what is really happening to the salmon below Grand Coulee Dam? It is hard to find anything tangible in this "interim" report, although the prefatory abstract claims that "results obtained to date indicate conclusive success in diverting the upper Columbia fish runs. . . ." We are told that the great hatchery at Leavenworth, designed with all the marvels of modern engineering to amaze the tourists, is without enough water to operate as designed, and that this is also true for the two smaller hatcheries. As for the record of performance, we find the following statements:

"The overall success obtained from artificial propagation during the initial seven-year period of the Grand Coulee Fish-Maintenance project has been only fair at best. It is, however, constantly improving as the many unanticipated problems are being identified and effectively solved by carefully designed and executed research" (p. 29). "The increased efficiency of artificial propagation, plus the reduced mortality among adult fish following cessation of trapping at Rock Island has done much in enabling artificial propagation, [their displaced comma] to fulfill its intended role in the Grand Coulee Fish-Maintenance project" (p. 42).

These statements evidently mean that while things have not worked out so well, they have worked out well enough. As for the claim of increased efficiency, inspection of the table on p. 43 indicates that the drop in total mortality for blueback salmon from 83.4% in 1940 to 23.7% in 1945 was accompanied by an 85% reduction in the number of eggs handled. This seems to be the same old story recorded for salmon hatcheries since 1872: the losses vary inversely with the magnitude of the operation. To be sure, more than three million blueback eggs were handled in 1943 (more than half the number handled in 1940) with a loss of but 24.3%, but we find from another table that more than half of these eggs were collected from the river instead of from the salmon, which would seem to indicate that artificial spawning is one of the primary causes of loss.

What about the other half of the project, the relocation of adult salmon in other streams tributary to the main stem of the amputated Columbia, so conclusively successful, according to the abstract? Some boiled down statistics all add up to this conclusion:

"It is not implied that these data accurately reflect trends in abundance of the salmon runs affected by the Grand Coulee Dam nor should these tentative conclusions be used in predicting future developments . . . conclusions, based on the meagre evidence available to date, strongly indicate that the upper river blueback runs have been benefitted by the relocation process and there is little reason to believe that either the spring or summer chinook runs have materially suffered thereby" (p. 54).

This all seems to be a rather feeble report after the expenditure of years of effort and unmentioned millions of dollars. In plain English, what is really going on?

JOEL W. HEDGPETH

A REPORT ON THE APPEARANCE OF THE FUNGUS ICHTHYOSPORIDIUM HOFERI IN THE HERRING OF THE NORTHWESTERN ATLANTIC. *Special Scientific Report Number 58.*

By Leslie W. Scattergood. United States Department of the Interior, Fish and Wildlife Service, Washington, D. C. Paper. 33 + 7 plates. 1948.

CONDITIONS AFFECTING SHELLFISH PRODUCTION IN LYNNHAVEN BAY, VIRGINIA, AND THE POSSIBILITIES OF IMPROVING THEM BY INCREASING TIDAL FLOW. *Special Scientific Report Number 61.*

By Walter A. Chipman, Jr. United States Department of the Interior, Fish and Wildlife Service, Washington, D. C. Paper. ii + 20 pp. + 9 plates; ill. 1948.

ANIMAL GROWTH AND DEVELOPMENT

EMBRYOLOGY OF THE PIG. *Third Edition.*

By Bradley M. Patten. The Blakiston Company, Philadelphia and Toronto. $3.75. xiv + 352 pp.; ill. 1948.

Many times I have heard premedical students acclaim the usefulness of this book, particularly as a constant reference in their laboratory study of the embryology of the fetal pig. As in previous editions, the illustra-

tions and the textual descriptions remain clear and fortunately simple.

In this new edition there has been no essential change in the form or scope of the book. Aside from improvement in the presentation of some of the original subject matter, revisions in accord with more recent, original observations, and enlargement of certain illustrations, there has been little change over the previous edition.

NELSON T. SPRATT, JR.

HUMAN EMBRYOLOGY AND MORPHOLOGY. *Sixth Edition.*

By Sir Arthur Keith. The Williams & Wilkins Company, Baltimore. $10.00. xii + 690 pp.; ill. 1948.

This rather thorough treatment of the anatomy of human development appears now in its sixth, thoroughly revised and enlarged edition. It is interesting that in the selection and extent of treatment of topics in the earlier editions, clinical utility was the criterion applied, but in later editions this utilitarian ideal has gradually retreated into the background. One feature which has remained unchanged throughout the several editions is the attempt to interpret the events of embryology in the light of evolution: embryology without its artistic aspects would perhaps be very dull to most students.

Perhaps the greatest change in the present edition is the expansion of the Notes and References at the end of each chapter. The inclusion of such an extensive bibliography adds greatly to the reference value of the text. Were the book printed on more expensive, glossy paper, with more elaborately executed illustrations, it might compete favorably with the more widely used premedical embryology texts in this country.

NELSON T. SPRATT, JR.

ANIMAL MORPHOLOGY

ATLAS OF HUMAN ANATOMY: *Descriptive and Regional. Volume I. Osteology, Arthrology, Myology.*

By M. W. Woerdeman. The Williams & Wilkins Company, Baltimore. $12.50. xii + 440 plates + xxiii pp. 1948.

This, the first volume of a projected three-volume work, deals with osteology, arthrology, and myology. It may be said at once that it is a first-rate contribution to the teaching literature of human anatomy. Volume II is to treat of splanchnology, the circulatory apparatus, the nervous system, and the sense organs, and volume III, of the peripheral vessels and nerves, and regional anatomy.

The present volume consists entirely of illustrations, with no text whatever. The nomenclature used is that of the Basle Nomina Anatomica. The main guiding principle used throughout has been that each separate figure should accurately portray a concrete example with all its individual features, and not show details gotten from more than a single dissection. This is a distinct rejection of the concept of an idealized "norm" or "canon" of the human body, an idea which obsessed even Vesalius and which has tended to dominate anatomical illustration for centuries. In line with this commendable departure from the tradition of the "textbook" man, a number of plates showing variations have deliberately been included. Similarly, growth changes receive attention, as in illustrations of the skulls of fetuses and new-born infants.

The drawings, largely in black-and-white, are realistic, accurate, and at the same time artistic. The labels are clear and adequate. There is an extensive index. Paper, printing, and binding are all excellent. The rather excessive price of the volume, however, will unfortunately tend to discourage its use by students.

W. L. STRAUS, JR.

PRIMARY ANATOMY.

By H. A. Cates. The Williams & Wilkins Company, Baltimore. $6.00. x + 478 pp.; ill. 1948.

This little volume is intended for use by non-medical students such as nurses, physiotherapists, occupational therapists, and health and physical educationists. Although it deals largely with morphology, some elementary physiology is included. The systematic rather than the regional approach is used, as being more readily grasped by beginning students. The skeletal, articular, muscular, and circulatory systems have received more detailed treatment than the digestive, respiratory, and genito-urinary systems—an expression of the author's belief that they are of greater importance to the non-medical student. By the same token, the nervous system is presented at considerable length. The illustrations are well chosen and simply but effectively executed. As an introduction to human anatomy, and with the audience in mind for which it is intended, this book achieves its purpose.

W. L. STRAUS, JR.

INTRODUCTION TO HUMAN ANATOMY.

By Carl C. Francis. The C. V. Mosby Company, St. Louis. $5.50. 470 pp. + 3 plates; text ill. 1949.

More than 300 excellent illustrations make up the framework of this book. The labeling is clear and direct, and the subject matter is well organized in harmony with the illustrations. A happy combination of "principles" and "facts" is reached in treating the

separate systems. The chapter on the skin and fasciae is outstandingly successful, although confined to only 14 pages. The glossary of 20 pages and an adequate index are also attractive features. Historical and biographical material and source references have been omitted.

J. A. CAMERON

SCHAFER'S ESSENTIALS OF HISTOLOGY. *Descriptive and Practical for the Use of Students. Fifteenth Edition. Edited by H. M. Carleton and E. H. Leach. Lea & Febiger, Philadelphia.* $6.50. xii + 655 pp. + 2 plates; text ill. 1949.

A textbook of histology that has in sixty-four years gone through 15 editions, completing 123,000 copies, needs little introduction. In this new edition the illustrations number over 660. The new photographs (reproduced without reduction) have been directly labeled, thus eliminating the use of letter-references in the legends. In general, this 15th edition is essentially the same in style and character as the original.

DAVID B. TYLER

LAMBERT'S HISTOLOGY. *An Introduction and Guide. Second Edition. Revised by Helen L. Dawson. The Blakiston Company, Philadelphia and Toronto.* $6.00. x + 696 pp.; ill. 1948.

This textbook is written primarily for the beginning student. It contains approximately 300 drawings and photomicrographs, many of which have been prepared especially for this textbook. Since the book is designed for beginning students, controversial material has been avoided. The references, suitably selected, are given with complete titles, and the book is adequately indexed.

DAVID B. TYLER

TEXTBOOK OF HISTOLOGY. *By José F. Nonidez and William F. Windle. McGraw-Hill Book Company, New York, Toronto, and London.* $6.75. xiv + 456 pp.; ill. 1949.

Many textbooks that pass across a reviewer's desk have little reason to be published. All that one sees in some of them is a sample of new authors and new covers, with little in between the latter to indicate a very diligent effort to contribute something new to the treatment of a subject. Authors of such textbooks, in certain instances, do not even take the trouble to rewrite a paragraph they have borrowed from another book, and the illustrations are usually obtained "through the courtesy of...." Any bibliography, if given at all, is often confined to a few inadequate references, incompletely cited, and the books are all too frequently poorly indexed. In general, what the authors of such textbooks succeed in doing is in getting their names on a book.

It is, therefore, a pleasure to come across such a textbook as that started by the late Professor Nonidez and completed by W. F. Windle. This histology book is for the beginner. It contains about 300 illustrations, nearly all of which were specially prepared for the book. The photomicrographs are excellent, a special effort was made to use as few magnifications as possible, and many are directly labelled. Well selected references, complete with titles, are given at the end of each chapter. Furthermore, the authors have seen fit to comment briefly on each article in order to acquaint the beginner in the field with what to expect from the article in question. Included, also, is a comprehensive list of motion pictures that can be used as visual aids, as well as the addresses of the producers or distributors of the films. As the authors have pointed out, not many laboratories are equipped to set up experiments in vitro or in vivo for beginning students, and motion pictures that can serve as good substitutes can be obtained at small rentals.

The book is well written, readable, and presents in concise form the fundamentals of the finer structures of the body, with emphasis, wherever possible, on functional aspects. In short, the reviewer highly recommends this book as a textbook for the beginning student.

DAVID B. TYLER

ANIMAL PHYSIOLOGY

ANNUAL REVIEW OF PHYSIOLOGY. *Volume XI. Edited by Victor E. Hall, Jefferson M. Crismon, and Arthur C. Giese. Annual Reviews and the American Physiological Society, Stanford, California.* $6.00. x + 643 pp. 1949.

This useful (and very technical) volume, like its predecessors, is primarily concerned with the classical divisions of mammalian physiology, each reviewed by a different specialist. Less orthodox chapters include Developmental Physiology, Radiation, and Permeability. The chapter on Muscle contains much material on protoplasmic structure. The problem of selecting and condensing material for review is epitomized by the fact that more than 4,500 authors have been cited. The editors "have pleaded with our reviewers to consider only those papers they deem particularly noteworthy... and to reduce coverage of other papers to mere listing." Some relief is expected in 1950, when the appearance of the *Annual Review of Psychology* and the *Annual Review of Medicine* will make unneces-

sary the inclusion of chapters on physiological psychology and various topics in pathology.

HENRY I. KOHN

THE MACHINERY OF THE BODY. *Third Edition.* *By Anton J. Carlson and Victor Johnson. The University of Chicago Press, Chicago.* $4.50. xxii + 639 pp.; ill. 1948.

The revisions made for this "new edition" have been very minor. A few new figures, various emendations, a section on blood transfusion and the blood types, a paragraph about the role of folic acid in pernicious anemia (already needing revision), a revised table of the vitamins which still omits riboflavin and other B group vitamins aside from thiamin and nicotinic acid, a reference to the use of radioactive iodine in treating hyperthyroid conditions, and a new section on the treatment of infections with chemicals (sulfa drugs; penicillin)—these are virtually all the changes. The textbook therefore remains what it was, a leader in its field; but it would be a mistake to call this much of a revision. The treatment of the vitamins especially needs to be reconsidered, not only because of its incompleteness but more particularly in order to relate the vitamins to the enzymes of cellular metabolism and to bring out the nature of the antagonistic or competitive action of sulfa drugs, penicillin, and the like. Vitamins, enzymes, and drugs appear in the present treatment to be entirely unrelated.

BENTLEY GLASS

LA RÉSORPTION ET LE TRANSPORT DES ACIDES GRAS: CONCEPTIONS NOUVELLES SUR LA DIGESTION DES GRAISSES. *Actualités Biochimiques, Number 11.* *By Pierre Favarger. Masson & Cie., Paris; Éditions Desoer, Liège.* 60 fr. (paper). 44 pp. 1947.

Along with a careful and critical review of recent work on the absorption and transport of fatty acids, Favarger has presented his own concepts on the mechanisms of lipid transport. Briefly stated, his schema is as follows. Upon reaching the thoracic duct, most of the lipids are in the form of triglycerides; to be utilized they must be phosphorylated by the liver. While a small fraction of the phosphatids are retained by the liver, the major portion returns to the general circulation. Most of the fatty acids appear to be metabolized as phosphatids, but the greater portion of the phosphatids are hydrolysed in the blood and then transformed into cholesterol esters. These esters appear in adipose and other tissues but are deposited in adipose tissue after their conversion to glycerides. Mobilization of the fatty acids is accomplished by the hydrolysis of the glycerides by a lipase. These fatty acids are then esterified with cholesterol, transported to other tissues and there utilized.

The physical state of the lipids in the blood stream is also discussed, particularly with regard to Frazer's investigation. Tentative interpretations of certain clinical findings, such as the marked lipemia found in certain individuals with icterus, are also given.

FRANCIS CHINARD

FACTORS REGULATING BLOOD PRESSURE. *Transactions of the Second Conference January 8–9, 1948, New York, N. Y.* *Edited by B. W. Zweifach and Ephraim Shorr. Josiah Macy, Jr. Foundation, New York.* $2.75 (paper). 170 pp.; ill. 1948.

A symposium held January 8–9, 1948, in New York. The transactions are made particularly useful by the inclusion of an extensive amount of discussion on the papers presented.

LORIN J. MULLINS

FUNDAMENTAL CONSIDERATIONS IN ANESTHESIA. *By Charles L. Burstein. The Macmillan Company, New York.* $4.00. xiv + 153 pp.; ill. 1949.

Out of his vast experience as a clinical anesthetist in civilian life and in the European theatre of the war, Charles L. Burstein has presented in this brochure a resumé of his fundamental experiences in anesthesia. The book should serve well for a refresher course in anesthesiology.

The writer has developed his plan of study by giving first a brief survey of the autonomic nervous system and respiratory mechanisms. Based upon these physiological discussions, the problems of respiratory disturbances during anesthesia are then discussed, and the methods of handling them are mentioned, together with their pharmacologic explanations. In addition, certain fundamental problems of the physiology of the circulatory system are discussed, and the anesthetist's interests in these are developed. Thus, certain chapters deal with the carotid sinus reflex, shock, and cardiac arrhythmias. The final chapters of the book deal with parasympathetic reactions, such as vagal cardiac slowing and gastrointestinal effects due to vagal stimulation.

The book is written from the viewpoint of the clinical anesthesiologist, and yet frequent references and charts are shown that deal with the experiments of the author or other investigators on laboratory animals. The book is well written and should certainly find a place

in the library of everyone who is interested in the field of anesthesia.

JOHN C. KRANTZ, JR.

ESSENTIALS OF ENDOCRINOLOGY. *Second Edition.* *By Arthur Grollman. J. B. Lippincott Company, Philadelphia, London, and Montreal.* $10.00. xxiv + 644 pp.; ill. 1947.

With minor changes this volume reproduces the first edition. Sections have been added on the hypothalamus, on the endocrine control of prostatic cancer, and a few other topics. Grollman's text is a lucidly written, elementary account of the endocrine glands, biased strongly toward providing rational explanations of disorders of these glands seen in the clinic.

H. R. CATCHPOLE

THE HORMONES: *Physiology, Chemistry and Applications. Volume I.* *Edited by Gregory Pincus and Kenneth V. Thimann. Academic Press, New York.* $13.50. xii + 886 pp.; ill. 1948.

The scope of this whole work, of which this is the first volume, is sufficiently indicated by its title, and the hope expressed by its editors that it will make a contribution to the orderly assemblage of knowledge would appear to be realized. Fifteen chapters (listed below) testify to an immense accumulation of information. These chapters are mostly cast in the familiar form of reviews with extensive reference lists, and collectively tend to defy criticism. To bring together such articles as these into large volumes provides a convenient work of reference, it is true. But some of the topics listed have already been most exhaustively reviewed (by the same or other authors) in publications readily available in libraries. Inevitably there arises, in the presentation of relatively compartmentalized reviews, the question of where the synthesis of such information is to begin. Readers will judge the several authors' success in such a joint venture by their ability to render comprehensible the existing information, to realize trends in their field, and to project their topics against the field as a whole.

The first volume contains chapters on plant and invertebrate hormones, work possibly unfamiliar to mammalian endocrinologists. Surprisingly omitted from this volume is any reference to the chemistry of the blood and urinary gonadotrophins, and of relaxin. Contents: Historical Introduction (Pincus and Thimann); Plant Growth Hormones (Thimann); Other Plant Hormones (Thimann); Hormones in Insects (Scharrer); Hormones in Crustaceans (F. A. Brown, Jr.); Hormones of the Gastrointestinal Tract (Greengard); The Physiology and Chemistry of the Parathyroid Hormone (Greep); The Internal Secretion of the Pancreas (Jensen); Assay of the Ovarian Hormones (Pincus); The Chemistry and Metabolism of the Estrogens (Pearlman); Chemistry and Metabolism of Progesterone (Pearlman); Biochemistry of Androgens (R. I. Dorfman); Chemistry and Metabolism of the Adrenal Cortical Hormones (Heard); Chemistry of Anterior Pituitary Hormones (Li and Evans); Hormonal Control of Mammary Growth (Folley and Malpress); Hormonal Control of Lactation (Folley and Malpress).

H. R. CATCHPOLE

RECENT PROGRESS IN HORMONE RESEARCH. *The Proceedings of the Laurentian Hormone Conference. Volume III.* *Edited by Gregory Pincus. Academic Press, New York.* $7.80. viii + 378 pp.; ill. 1948.

The third volume of *Recent Progress in Hormone Research* covers the Laurentian Hormone Conference of September, 1947. As in previous conference reports, the papers are grouped in selected topical fields of academic and clinical interest, and the formal presentations are enlivened by discussions. In a wide range of topics one's personal interest will tend to single out a few. Histochemical methods applied to hormone research were discussed by Dempsey and by Leblond. Miescher has written authoritatively on structure and function in sex steroids, based largely on recent work in the Swiss laboratories, including studies on the highly active estrogens of the doisynolic acid series. The chemistry and biochemistry of the growth hormone were brought up to date by Li and Evans. Hamilton, in a most interesting contribution, uncovered a startling number of disadvantages of being male. The paper of Heller and Nelson on Testes-Pituitary Relationship in Man provoked a lively discussion of the question of hormone "utilization" by its target organ. Hormones in Hypertension were considered by Corcoran and by Selye. Other contents: Steroid Excretion in Health and Disease (Lieberman and Dobriner); Urinary Steroids in Adrenal Disease and Metabolism of Adrenal Hormones (Mason); Biology of the Interstitial Cells of the Testis (Hooker); The Testis in Human Hypogonadism (Nelson and Heller).

H. R. CATCHPOLE

THE PARATHYROID GLANDS AND METABOLIC BONE DISEASE. *Selected Studies.*

By Fuller Albright and Edward C. Reifenstein, Jr. The Williams & Wilkins Company, Baltimore. $8.00. xxvi + 393 pp.; ill. 1948.

The name of the senior author has become synonymous with bold clinical research in calcium metabolism, with theories respecting it, and with lucid exposition thereof. The spirit of these inquiries is retained in this volume of selected studies from the Metabolic Ward of the Massachusetts General Hospital. Here one finds meticulous metabolic studies and intimidating charts illustrating them, combined with diagrammatic homunculi, excellent illustrations, and a very readable text that is by no means free of argument, or of a certain amount of leg-pulling. Covered are the iso-, hyper-, and hypo-parathyroid states, and the often bizarre syndromes of bone disease proper: osteoporosis, osteomalacia, polyostotic fibrous dysplasia (Albright's disease, non sine protest), and Paget's disease. Hypotheses, one is warned, are subject to change without notice, and contentious readers who disagree with this or that interpretation may already be on the side of the authors. In respect of medical terminology, the reviewer would accept "codfish vertebra" as a fine, if humble, tribute to the Hub of the Universe, but, in the descriptions of pigmented areas, he would prefer "coast of Norway" and "coast of Africa" to the coasts of Maine and California, respectively.

H. R. CATCHPOLE

THE EFFECT OF LIGHT INTENSITY AND DAY LENGTH ON REPRODUCTION IN THE ENGLISH SPARROW. *Bulletin of the Museum of Comparative Zoölogy at Harvard College. Volume 101, Number 3.*

By George A. Bartholomew, Jr. Museum of Comparative Zoölogy at Harvard College, Cambridge. $1.50 (paper). ii + pp. 433–476 + 10 plates. 1949.

The research reported on in this paper helps to clear up some loose ends that have resulted from various investigations on the effect of photoperiods on the avian gonad cycle. One such factor not quantitatively determined with any conclusive result so far is the effect of light intensity. English sparrows were exposed to 16-hour days of artificial light from fluorescent lamps at intensities ranging from 0.04 to 244 foot candles. Controls were exposed to only 8 hrs. at 10.0 foot candles. Under an intensity of 0.04 f.c., no increase in spermatogenic activity was noted. A moderate activity occurred at 0.7 f.c., and full activity (i.e., maturation of sperms) at 10 f.c. and above. A similar experiment was conducted at the low intensities, but for 46 days instead of 25 days. After this longer exposure, it was found that 0.7 f.c. had a pronounced effect, but not 0.04 f.c. Another experiment designed to obtain a quantitative evaluation of the relationship between daylength and degree of gonadal development was conducted. Different groups of sparrows were exposed to 25–27 f.c. for periods of 10, 12, 14, 16, and 24 hrs. daily. The maximum increase in effectiveness occurred between day-lengths of 12 and 14 hrs. The eight-hour increase from 16 to 24 hrs. had only one-fourth as great an effect as the two hour increase from 12 to 14 hrs. The differences between 14, 16, and 24 hr. exposures were slight. Even an exposure of 10 hrs. produces some spermatogenic activity. Females, which are known to respond to a lesser extent than the males, generally reacted in much the same manner as the males.

These results should rule out the effect of wakefulness as a cause of gonadal recrudescence, since all intensities above that necessary to keep a bird awake have the same effect. Bartholomew leans to the theory of Benoit and Ott that light passes through the transparent material of the eye and the thin bony wall of the skull to stimulate the pituitary region directly. If this be true, then it is relatively easy to understand how increasing intensities of light would elicit a progressively greater response from the pituitary. In the fall of the year, 244 f.c. were more effective than 10 f.c., whereas in January both had the same effect. This is an indication of seasonal variation in the response of the pituitary to light or of the gonads to gonadotrophins. Recent work by Miller indicates that the former is correct.

This work has important ecological significance. In the discussion some of these problems have been considered. One fact that still needs to be determined is the time at which sparrows open and close their eyes, so that the daylength to which the bird is exposed may be calculated accurately, for even before sunrise and after sunset the illumination is greater than the effective 10 f.c. Moonlight produces only 0.02 f.c. and is therefore ineffective. Clear and cloudy days could, if continued for a sufficiently long period, have a greater effect than the naturally increasing or decreasing photoperiod. These data provide essential basic information for all future work on photoperiodic responses in birds.

HENRI C. SEIBERT

THE SUPERSENSITIVITY OF DENERVATED STRUCTURES: *A Law of Denervation. Experimental Biology Monographs.*

By Walter B. Cannon and Arturo Rosenblueth. The Macmillan Company, New York. $5.50. x + 245 pp.; ill. 1949.

In this book are assembled the results of a thorough search, by Walter B. Cannon and his associates, for the generality of a biological principle: namely, that mammalian tissues become more sensitive to excitatory and inhibitory agents when deprived of their normal innervation. The sensitization is greatest when the axones terminating in the tissue are caused to degener-

ate, but it is also considerable when axones of higher order neurones are severed. This generality has been expressed by Cannon as "a law of denervation" in the following words: "When in a series of efferent neurones a unit is destroyed, an increased irritability to chemical agents develops in the isolated structure or structures, the effects being maximal in the part directly denervated." For example, the cat's nictitating membrane retracts in response to a lower than normal concentration of adrenalin after the preganglionic fibers that supply the superior cervical ganglion have degenerated, and to still lower concentrations after removal of the post-ganglionic fibers.

In addition to the studies on sensitization, experiments on some possibly allied phenomena are reviewed in the book. These include a chapter on the spontaneous activity of denervated structures and another on the "crossed phrenic" phenomenon. It is particularly welcome to find a critical summary of the literature on the latter, still unexplained and intriguing property of the respiratory system. The final chapter considers some interesting implications of the principle of sensitization by denervation in problems of the conservation of isolated organs, spinal shock, central reorganization after nervous lesions, and Jacksonian epilepsy.

Sensitization by denervation was found in all of the many tissues investigated: in smooth muscles of the nictitating membrane, iris, blood vessels, pilomotors, intestine, uterus, and bronchioles; in melanophores, glands, the heart, and striated muscle; and in neurones of the spinal cord and possibly in some of the higher centers. It is well to emphasize that the concentration required for characteristic effect by a chemical agent was reduced by denervation whether that effect was excitatory or inhibitory.

One might expect that if a tissue becomes sensitized to chemical agents following complete denervation, then it would also become sensitized to impulses arriving over residual nerve fibers following partial denervation. In agreement with this supposition were the results of experiments on partially denervated smooth muscles, glands, and striated muscles, as well as on sympathetic ganglion cells and spinal neurones. It must be admitted that these observations, considered by themselves, are less convincing demonstrations of an increased sensitivity of the respective cells than the experiments showing sensitization to chemical agents. This is because the authors have not discussed the possibility that conditions may change, so that a stronger than normal stimulus is delivered by the residual presynaptic nerve fibers, due, for example, to the formation of additional endings. However, it seems clear that there is an increase in the capacity of a given number of neurones to excite other cells, whether this be due to an increased excitability of the postsynaptic cells, to an increased strength of stimulus delivered per presynaptic nerve impulse, or to a combination of these two mechanisms. It is likely that an increased excitability is at least partly responsible, in view of the clearly demonstrated increased sensitivity to chemical agents.

Throughout the book, pertinent experimental evidence is stated with meticulous care for clarity and completeness, including the details of the experimental procedures used, and this care permits the reader to evaluate the various conclusions and hypotheses to a considerable degree without having to refer to the original papers. The book should accordingly become an important contribution toward the present application and future interpretation of a group of fascinating but as yet incompletely explained biological phenomena.

MARTIN G. LARRABEE

ODORS. *Physiology and Control.*
By Carey P. McCord and William N. Witheridge. McGraw-Hill Book Company, New York, London and Toronto. $6.50. x + 405 pp.; ill. 1949.

Despite the enormous number of investigations which have been concerned directly with the phenomenon of odor, our understanding of the basic principles of the physiology, chemistry, and physics of odor remains confused. Thus no book treating of the subject of odor at the present time can offer any truly new fundamental information. Nor is it possible, or even advisable, in the state of our current knowledge to compile and to recount all the factual information which heretofore has been reported in the literature. At best, one can but select from the vast library of facts those which highlight the field. To accomplish this in an impartial manner in the space of 272 text pages is exceedingly difficult. The present authors have attempted to present a comprehensive summary of the latest state of knowledge of odor perception, measurement, classification, and regulation. The result is a book which may be somewhat disappointing to the physiologist but which should be of great value to those who are interested in the industrial aspects of odor production or control. Where most of the previous volumes dealing with the subject of odor have been concerned primarily with topics of interest to the perfumer, the present volume is devoted more extensively to the offensive odors.

The space allotted to physiology is somewhat less than thirteen pages, and in view of this the subtitle of the book is rather misleading. In that brief space there is a discussion of three theories of odor stimulation: the physical, the chemical, and the electrochemical. The last mentioned is presented "on the basis of frankly labeled speculation." The chapter continues with a few remarks on odor focusing and selection, the interrelation of odor and taste, adaptation, fatigue, threshold, and acuity in primitive races. The

bulk of the book is concerned with the sources of objectionable odors in nature and in industry, and with their control.

After a short introduction and a brief account of the anatomy of the olfactory system, followed by that chapter on physiology already mentioned, the authors discuss the relation between chemical constitution and odors, in a chapter which is essentially a condensation of Chapter 9 of Moncrieff's book, *The Chemical Senses*. A short factual account of odor classification follows. The chapter dealing with odor detection and measurement is concerned only with devices designed for use with human beings. It is primarily descriptive.

The remaining chapters deal with the influence of odors on health and comfort, body odors, household odors, industrial odors, odors of waters and foods, the offensive trades, air conditioning, chemical and physical destruction of odors, odor masking and cancellation, the serption of odors, odors as warning agents, attractants and repellents, odor surveys, and the legal aspects of odor nuisances. In these chapters the authors have done well indeed in their task of bringing together and integrating a vast amount of scattered and frequently inaccessible information. The value of this book to those who are interested in the industrial aspects of odor should be great. There are 117 pages of bibliography and a profusion of fine illustrations.

V. G. DETHIER

THE PHYSIOLOGY OF TASTE. *Meditations on Transcendental Gastronomy. A Complete Translation from the French.*

By Jean Anthelme Brillat-Savarin, with preface by Charles Monselet. Liveright Publishing Corporation, New York. $2.49. liv + 360 pp. 1948.

There is, of course, only a little physiology in this literary classic of gastronomy, written leisurely in the quarter century from 1800 to 1825 by a man whose common sense assured him that a really good meal needs a full and prolonged digestion. Brillat Savarin, whose name even today graces some of our best-known eating-places, lived in troublous times. Through the turmoil of the French Revolution and a self-imposed exile in the United States, then amidst the Napoleonic wars, and on into the dyspeptic days of the Restoration he preserved a sound digestion and an imperishable conviction that life's finest achievement is a perfect fondue or a fowl stuffed with truffles. Never vulgar, Brillat Savarin, like Horace, savored the simple as well as the elaborate. His ideal was not Lucullus nor his god Bacchus, though he appreciated a banquet and a good wine. In his own way, by anecdote and recipe, he paints a fuller picture of his times than most historians. The general views of the educated man of the early 19th century regarding the sense of taste, the nature of digestion, the role of foods in the body, hunger, thirst, appetite, rest, sleep, and dreams mingle with advice on how to treat corpulence, leanness, or exhaustion and how to live a long life. Most interesting to the biologist, and in particular to the student of nutrition, is the meditation entitled A Philosophical History of Cookery, together with other sections that describe the introduction into the European diet of certain articles such as sugar, coffee, chocolate, and alcohol (distilled liquors as distinct from natural wines).

This excellently printed edition of the paramount work of its kind is a bargain at what is nowadays a remarkably low price for a book.

BENTLEY GLASS

ANIMAL NUTRITION

FOOD AND HEALTH. *Second Edition.*

By Henry C. Sherman. The Macmillan Company, New York. $4.00. xii + 290 pp. 1947.

For a layman's account of what one should know about nutrition, it would be hard to find a more authoritative book than this. It is simple and direct in style—very matter-of-fact, indeed—and lacks the color and interesting historical and topical anecdotes and illustrations so characteristic of *Man, Bread, and Destiny*, a book with a similar aim written by C. C. and S. M. Furnas. The organization of the 2nd edition of *Food and Health* and the extensive tables and summaries contained in its six appendices follow the plan of the first edition, which was reviewed in Q. R. B., 10: 481 (1934). Of the 24 chapters of the book, 8 deal with the vitamins (even so, vitamin E and the newer members of the B group are not included). The remaining chapters cover fuel foods, proteins and amino-acids, mineral elements, foods by groups, and various general topics. Dietary allowances have been revised on the basis of the National Research Council's recommendations of 1945. In short, while biologists will find the book too elementary a treatment of the subject for use as a reference work, they may wholeheartedly recommend it to anyone who wants a sound introduction to the field of nutrition.

BENTLEY GLASS

FOOD POISONING. *Second Edition.*

By G. M. Dack. The University of Chicago Press, Chicago. $3.75. xii + 184 pp. 1949.

The earlier edition of this important publication has been expanded to include recently published information. The newer material deals, for example, with problems which became prominent because of wartime conditions, such as intoxication due to bleached flour,

contamination of egg powder, purification of botulinus toxin, and the need for differentiating infections of unknown etiology from food poisoning. An author index has been added. With about forty more pages than before, this is still a short though authoritative presentation of the subject. There is relatively little technical detail in it; the text is clear and readable and is illustrated with well-chosen histories of cases and outbreaks. The book is recommended imperatively for reading by physicians, health officers, and teachers, and for persons interested in sanitation, nutrition, or food industries.

HARRIETTE D. VERA

BIOPHYSICS

MATHEMATICAL BIOPHYSICS. *Revised Edition.* *By N. Rashevsky. The University of Chicago Press, Chicago.* $7.50. xxiv + 669 pp.; ill. 1948.

This new edition of Rashevsky's *Mathematical Biophysics* includes the text of his first book, bearing the same title (reviewed Q. R. B., 14: 106. 1939), in addition to the major part of his *Advances and Applications of Mathematical Biology* (reviewed Q. R. B., 15: 393. 1940). Also incorporated into this revised edition is a new section treating the problem of the organism as a whole and the organic world as a whole.

The application of mathematical reasoning to any branch of science has always been initiated in the belief that such a procedure would lead to the correlation of many related facts into a neat formulation from which deducible conclusions would follow and thus suggest further experiments. The notable success of this methodology in physics and the belief that it can be beneficially extended into the field of biology have been the motivations of the Rashevsky school. The first part of the book is concerned with the formulation of a diffusion equation to account for the flow of metabolites into cells and the resulting flow of waste products out of them. The consequences of such diffusion are applied to oxygen consumption and cellular respiration in general. Since diffusion fields create mechanical forces, a theory is proposed that attempts to explain cell division in these terms. To avoid insurmountable mathematical difficulties, only simple idealized cases such as spherical cells are treated in any detail. An attempt is made, however, to evaluate such simplifying assumptions in applying the conclusions to actual cases.

An interesting mathematical formulation of the cancer problem is presented in very general terms. The basic assumptions made here are that some specific factor determines the rate of growth and multiplication of each cell, and that some other factor exerts an inhibitory influence on the growth of cells. It is quite illuminating to observe how the application of the mathematical method makes it possible to draw conclusions from these and other assumptions.

A rather extensive application of the mathematical method is made in the consideration of the problems related to excitation and conduction in peripheral nerves and the biophysics of the central nervous system. The basis of much of this work is the so-called two-factor theory of excitation. The theory assumes that the nerve contains two substances. The ratio of the concentrations of these substances determine whether or not excitation can occur. With these assumptions, the simple facts of nerve conduction are explained and applied with excellent success to a few experimental data. Central excitation and inhibition, discrimination of intensities, psychophysical discrimination, conditioned reflexes, rational learning and thinking, and visual perception and aesthetics are examples of the topics subjected to mathematical analysis.

The last part of the book is concerned with a mathematical approach to general biology, a mathematical attempt to consider the organism as a whole. The forms of plants, such as the shapes of trees, are considered in terms of the general metabolism of the plant and the structural strength of its parts. The locomotion and form of snakes is accounted for by the friction of the moving snake against the ground and the manner of its muscular contraction. The form and locomotion of certain quadrupeds is analysed by considering a quadruped as a bar supported at its ends. On purely mechanical considerations concerning sagging of the trunk, the ratio of the weight of an animal to the length of its trunk is determined, and likewise the relation between the cross-section of the legs and the weight of the animal. The conclusion is drawn that the weight of an animal will determine, to a great extent, its general form. Relations between the form of an animal and its locomotion are also established.

It is unfortunate that the author does not work in collaboration with an experimental laboratory, for much of this theoretical work still demands experimental confirmation. The utility of any theoretical science depends entirely upon its ability not only to correlate existing facts into theories, but also to predict new relationships which may be sought through experimentation. The amount of actual data cited in this book is extremely small. Besides the interest which the theories presented may evoke, the biologist who is interested in attempting to formulate some of his experimental data into mathematical terms will also find in this book an excellent guide.

ELLIOT JUNI

THE METRIC SYSTEM OF WEIGHTS AND MEASURES. *The National Council of Teachers of Mathematics: Twentieth Yearbook.*

Compiled by the Committee on the ***Metric System,*** *J. T. Johnson, Chairman. Bureau of Publications, Teachers College, Columbia University, New York.* $3.00. xvi + 303 pp.; ill. 1948.

The problem of converting this country's system of measurement into a rational one is considered in this collection of short articles and letters. Indeed, since chiefs of the armed forces, supply agencies, the Bureau of Standards, many heads of industries, and a great number of educators all agree that the present irrational system of measurement is deplorable, it is surprising that the United States has not long ago converted to the use of the metric system. All the arguments presented have, I suspect, been presented many times before. There is nothing in the way of a detailed plan for action of any sort that would analyse the various objections to metric conversion and find some way to meet them.

L. J. MULLINS

ELEMENTARY NUCLEAR THEORY. *A Short Course on Selected Topics.*

By H. A. Bethe. John Wiley & Sons, New York: Chapman & Hall, London. $2.50. viii + 147 pp.; ill. 1947.

The title of this work may be a little confusing, since the book is elementary *theoretical* physics, and as such presupposes a rather advanced level of mathematical training for the reader. The first part of the book outlines a descriptive theory of nuclei and is quite easy to read; while the last three-fourths of the book, dealing with the quantitative theory of nuclear forces, is almost certain to be unintelligible to any biologists who have not had considerable training in advanced mathematics. The book represents a series of lectures on the more general aspects of nuclear forces, and was prepared for chemists and physicists who lacked special training in theoretical physics.

L. J. MULLINS

RADIOACTIVE MEASUREMENTS WITH NUCLEAR EMULSIONS.

By Herman Yagoda. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. x + 356 pp.; ill. 1949.

The recent development of special photographic materials for the detection of nuclear particles has made quite desirable a monograph that would summarize for the research worker the properties of these emulsions and the techniques for their use. This book is a resumé of the methods which have been used for the autoradiography of biological materials, as well as for cosmic ray and geological research. A great deal of material on the techniques of the photography of nuclear particles is included, and on the biological side there is an excellent discussion of the practical limitations of autoradiography. Since it is to be hoped that the resolution of biological autoradiographs will be much improved in the future, it would be interesting to see a theoretical treatment of the possibilities inherent in radioautographic methods. This, however, has not been supplied. Some of the newer work in the biological field has also not been reported, but this is quite understandable in view of the scope of a book which covers both the physical and biological fields where nuclear emulsions have been used.

L. J. MULLINS

BIOCHEMISTRY

OUTLINES OF BIOCHEMISTRY. *Third Edition.*

By Ross Aiken Gortner: edited by Ross Aiken Gortner, Jr. and Willis Alway Gortner. John Wiley & Sons, New York; Chapman & Hall, London. $7.50. xvi + 1078 pp.; ill. 1949.

Books which treat biochemistry as a subject in its own right, rather than as it applies to medicine or agriculture, are very much to be desired. This third edition by the late Professor Gortner is such a work. The volume has been revised by former students of Gortner, and while retaining the general plan of previous editions, considerable revision within the various subdivisions has brought much of the subject matter up to date.

Biochemistry is treated under the following general headings: colloids, proteins, carbohydrates, lipids, plant pigments, and biochemical regulators. One must admit that such a selection of topics is quite arbitrary, but it is also clear that anything like a complete coverage of topics commonly considered to belong to biochemistry would make a work a multi-volumed affair. It seems a little unfortunate that inorganic metabolism, a subject which has advanced so rapidly in recent years through the extensive use of artificial radioisotopes, has not been treated in this book. In general, the exposition of those subjects covered is excellent, and the volume as a whole is to be highly recommended.

L. J. MULLINS

BIOCHEMICAL PREPARATIONS. *Volume 1.*

Edited by Herbert E. Carter, Eric Ball, Carl Niemann, Robert R. Sealock and Esmond E. Snell. John Wiley & Sons, New York; Chapman & Hall, London. $2.50. xii + 76 pp. 1949.

This new annual publication will do for biochemistry what has been done in the past for both organic chemistry and biochemistry, jointly, by the series *Organic*

Syntheses. The first volume contains methods for preparing 16 chemicals, including such key substances as adenosine diphosphate and triphosphate, l-alanine and l-serine, casein, diphosphopyridine nucleotide, the α-glucose-1-phosphates, l-glutamine, lycopene, lysozyme, and d-tyrosine. There is a subject index.

ASPECTS ACTUELS DE L'ENZYMOLOGIE. *Un Symposium dans le Cadre du VII^e Congrès de Chimie Biologique (Liege, 3–6 Octobre 1946). Actualités Biochimiques, Number 10.*

By L. Massart, C. Lutwak-Mann, T. Mann, J. Roche, H. Veldstra, R. A. Peters, etc. Editions Desoer, Liege; Masson et Cie., Paris. 180 fr. (paper). 147 pp. + 2 plates; ill. 1947.

This booklet is a record of three sessions of the 7th Congress of Biological Chemistry, held at Liege, October 3 to 6, 1946.

These particular sessions were devoted primarily to enzymology. About twenty-one papers were presented, the majority containing results of original investigations by the authors. Among the papers read were contributions by R. A. Peters and M. Dixon detailing some of the findings on lachrymators. F. Dickens summarized briefly his work on oxygen poisoning of brain respiration and the relation of metallic ions to this phenomenon. Myrbäck discussed the action of amylase, and Bertrand the properties of laccases. Various aspects of the biochemistry of the phosphatases were taken up by Roche, Courtois and Plumel, and Jeener. While the book has a table of contents, it lacks both subject and author indexes.

S. SPIEGELMAN

LES DIASTASES. *Collection Armand Colin (Section de Chimie). Number 251.*

By Paul Fleury and Jean Courtois. Librarie Armand Colin, Paris. 150 fr. (paper). 216 pp. 1948.

This little volume represents an attempt by the authors to survey for readers of the French language the present status of enzymology. The usual subjects, including the natural distribution of enzymes, methods of extraction and purification, enzyme constitution, and the kinetics of enzyme reactions are discussed. The effects of various physical and chemical agents on enzyme reactions are also detailed. The last of the nine chapters of the volume is concerned primarily with the classification of the various enzymes.

There is little in this volume which is not available in a far more exact and complete form to readers of either the English or German literature on enzymology. Very few references are given for the various experimental facts cited. At the end, a few general references, e.g., *Advances in Enzymology*, are noted. The fact that the book is not indexed would seem to the reviewer to decrease considerably its usefulness to the French reader.

S. SPIEGELMAN

THE CHEMISTRY AND TECHNOLOGY OF ENZYMES.

By Henry Tauber. John Wiley & Sons, New York; Chapman & Hall, London. $7.50. x + 550 pp.; ill. 1949.

The present volume represents an expansion of the author's previous book, *Enzyme Technology*. Aside from bringing the citation of the pertinent literature up to date, the primary difference between the two volumes is that the new book discusses the general properties of the different types of enzymes, as well as their application to various technological processes.

One half of the volume is devoted to a section entitled The Chemistry of Enzymes. Here the author undertakes to describe the characteristics of enzymes, their modes of action, their substrates, procedures for their assay, and the nature of the active groups. Tauber follows the usual classification of enzymes, which is based in part on the substrate acted upon, and in part on the type of chemical reaction mediated. Also included are useful accounts of methods for the extraction and purification of enzyme preparations, as well as for the synthesis of certain of the important substrates and intermediates.

The second half of the volume concerns itself with the technological uses of enzymes and enzyme preparations. This aspect of the subject is covered thoroughly and authoritatively. Industrial uses discussed extend from the enzymatic clearing of beer to the employment of enzymes in the dry cleaning of clothes. This last part of the volume can hardly fail to impress the reader with the manifold diversity of the extracellular usefulness of enzymes, aside from the more obvious one of providing many biochemists with a livelihood. The book is well indexed by both subject and author.

S. SPIEGELMAN

NUCLEIC ACIDS AND NUCLEOPROTEINS. *Cold Spring Harbor Symposia on Quantitative Biology, Volume XII.*

The Biological Laboratory, Cold Spring Harbor, L. I., New York. $7.00. xii + 279 pp. + 21 plates; text ill. 1947.

This volume is an invaluable one for students in practically every field of biology. During the past few years a tremendous amount of research has been done, emphasizing the importance of the nucleic acids for genetic continuity and alteration and for normal and abnormal growth and development. Leading ex-

ponents in this research are among the contributors to the Cold Spring Harbor Symposia, vol. XII. The volume includes twenty-five papers. Although they are arranged alphabetically by author, they fall logically into several groups.

In the first group there are four papers which deal with chemical aspects of the subject. Outstanding in this group are the brilliant papers of J. M. Gulland and of L. Michaelis, entitled respectively, The Structures of Nucleic Acids, and The Nature of the Interaction of Nucleic Acids and Nuclei with Basic Dye Stuffs. Gulland has stated concisely and authoritatively the current knowledge of the molecular and macromolecular structure of the nucleic acids, and has included in his discussion an evaluation of the tetranucleotide hypothesis. Michaelis' paper constitutes the best exposition of histological dyeing that the reviewer has ever seen. At the outset of the article the author justifies his stand, that the staining of uncombined nucleic acids in aqueous solutions and the staining of cells and nuclei can be dealt with on the same basis. In this introductory section he establishes the important point that the behavior of any one of the basic dyestuffs toward any kind of nucleic acid is independent of the special chemical nature and molecular size of the nucleic acid. He then proceeds to a consideration of the optical properties of basic dyes in solution and in the adsorbed state; the absorption spectra of toluidine blue are used chiefly as illustrative material. The concluding section of the paper is on the specific effects of nucleic acids on the absorption spectra of several basic dyes, including pyronin and toluidine blue.

The second group of papers deals with the relationship of nucleic acids to the maintenance, growth, and differentiation of cells and tissues. An article by J. N. Davidson considers the exact quantities of ribose and desoxyribose nucleic acids found in normal and pathological tissues under various conditions of growth and function. W. C. Schneider's paper on normal and neoplastic tissues likewise deals with quantitative nucleic acid determinations. The use of cytochemical and microspectrographic technics, as developed by Caspersson for the determination of protein and nucleic acid concentrations in single cells, is described in a paper by B. Thorell. Thorell then shows how changes in concentration of protein and ribose nucleic acid during erythropoiesis can be followed by these technics. The evidence presented supports Caspersson's general theory regarding the function of the nucleolus and ribose nucleic acid in the synthesis of cytoplasmic proteins. J. Brachet's paper deals with nucleic acid metabolism during embryogeny. In a discussion of the experimental findings reported, the author considers several theoretical possibilities regarding the role of the ribonucleic acids in the induction of the neural tube. Finally, a paper by S. Spiegelman and M. D. Kamen may be regarded as belonging to this second group of papers. The authors consider nucleic acid turnover in relation to protein synthesis. They take the view that although it seems plausible to assume that protein synthesis is critically controlled by nucleic acids, the experimental evidence is far from convincing.

A third group of six papers deals with nucleic acids in viruses and bacteria and constitutes essentially an extension of volume XI of the Cold Spring Harbor Symposia, on Heredity and Variation in Microorganisms.

Finally, the nucleic acids of the nucleus and chromosomes are considered in a fourth group of papers. Opportunity was thus provided for the British (E. and E. Stedman) and the American (A. Mirsky, A. Pollister, and H. Ris) workers to continue their disagreement regarding the chemical nature of chromosomes. For the reviewer, the most valuable paper in this group seemed that by Pollister and Ris, which describes exact procedures for the determination of nucleic acid and protein fractions in individual cells in microscopic preparations.

HELEN CROUSE

ORGANIC CHEMISTRY FOR STUDENTS OF BIOLOGICAL SCIENCES.

By Robin Charles Burrell. Burgess Publishing Company, Minneapolis. $2.75 (paper). iv + 242 pp.; ill. 1947.

The idea of an organic chemistry text for students of biological science seems a commendable one. After an introduction to organic chemical nomenclature and typical structures, the bulk of the text covers the structure and reactions of fats, carbohydrates, amino acids, amides and amines, proteins, and miscellaneous compounds of biological interest. The book is lithoprinted and has a spiral binding, features which suggest that frequent revisions may appear. The general choice of subjects and the presentation seem very good.

L. J. MULLINS

ORGANIC SYNTHESES. *An Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals. Volume 28.*

Edited by H. R. Snyder. John Wiley & Sons, New York; Chapman & Hall, London. $2.50. vi + 121 pp.; ill. 1948.

Methods for synthesizing 37 organic substances, from 2-acetothienone to vinyl chloroacetate, and a cumulative index for this series of publications covering volumes 20 through 28. From this volume on, biol-

ogists will find those preparations of most interest to them in the new annual publication, *Biochemical Preparations*, rather than here.

A TEXTBOOK OF COLLOID CHEMISTRY. *Second Edition.* *By Harry Boyer Weiser. John Wiley & Sons, New York; Chapman & Hall, London.* $5.50. x + 444 pp.; ill. 1949.

Just what constitutes the subject matter of colloid chemistry is a question capable of a wider variety of interpretations than for most other branches of chemistry. The student must, therefore, try to decide just what subjects he wants to find covered in a general book on colloids. The present volume is a thoroughgoing treatment of "classical" colloid chemistry—indeed, the author remarks that his book is patterned on *Kapillarchemie*. The subject matter of this book is divided into the following sections: adsorption; sols, gels, emulsions and foams; aerosols and solid sols; and applications to contact catalysis and dyeing. Each section is treated rigorously with respect to the derivation of equations used, and the subject matter is written in an eminently readable style.

However, there really seems to be little excuse for a second edition of this book, inasmuch as it is not very up to date. Few of the references are dated later than 1940; there is only the barest mention of the electron microscope, and no mention at all of the results it has produced in the field of colloid chemistry (such as the work on the ultra-structure of the V_2O_5 gels by Ardenne and by Frey-Wyssling). Similarly, there is little material on polarization-optical studies of colloids. A brief statement of the phenomenon of flow double refraction does not dorrectly explain that phenomenon.

The book may be considered as very adequate for chemists who are interested in the industrial applications of colloid chemistry, but is not very suited to the needs of the student in the biological sciences.

L. J. MULLINS

SMALL WONDER. *The Story of Colloids.* *By Gessner G. Hauley. Alfred A. Knopf, New York.* $3.50. xii + 220 + x pp. + 12 plates; ill. 1947.

The author has a good style for popularizing science, and in the fields he knows and where he has had expert advice he has presented an excellent summary of colloidal phenomena. Unfortunately, he neither knows the field of biology nor appears to have sought the assistance he so clearly needs in dealing with biological topics. The result is a book that cannot be recommended in spite of its many excellent features. His biological errors are of the most rudimentary sort, e.g., "Whether every egg and sperm cell carries all the necessary potentialities within it, or whether the cells become distinguished from one another by some specialized mechanism at an early stage of development of the embryo is still a mystery" (p. 15). Biology had done with this antithesis fifty years ago. Again, "the largest animal on earth is the whale, although prehistoric reptiles were considerably larger . . ." (p. 24) is no more accurate than the diagrams of sizes in various ranges of magnitude that accompany this part of the text. Other statements are simply ludicrous: ". . . blood contains two quite different kinds of cell, one of which is dyed [sic] red . . . the red corpuscles . . . serve as a positive agent in transporting food products, oxygen, and carbon dioxide through the body. . . . A third kind of cell structure is the blood platelet . . . whose exact function is unknown" (pp. 130–131). "An excess of white corpuscles induces [sic] an incurable condition known as leukemia" (p. 134). "Enzymes occur in dozens of places in both plants and animals. In the latter they populate the blood, the bony structure, and the liver" (p. 206). "Nature sees to it that exactly enough of each kind of hormone is produced. . . . The hormones continue where the genes left off . . ." (p. 208). Photosynthesis produces proteins rather than glucose (p. 219), and "osmotic pressure is in a sense the basic factor in growth . . . " (p. 212). Mutatis mutandis, this would be a good book. The author is to be commended for seeing that the story of colloids takes him often and deep into the realm of biology. He desperately needs a guide, however, in that foreign country.

BENTLEY GLASS

EXPERIMENTAL IMMUNOCHEMISTRY. *By Elvin A. Kabat and Manfred M. Mayer; with a foreword by Michael Heidelberger. Charles C. Thomas, Springfield, Illinois.* $8.75. xvi + 567 pp.; ill. 1948.

Immunochemistry has been developing with great rapidity in recent years and increasingly large numbers of students and investigators have been entering this field. Undoubtedly all of the newer, as well as many of the experienced, workers have felt the lack of a single reference textbook that would serve as guide to the various techniques and procedures that studies along this line generally require. The present text fills this gap admirably. The authors were evidently well prepared for this task, since they were for many years members of a laboratory that has contributed greatly to the theoretical and practical development of immunochemistry. The book reflects, too, the intimate familiarity of the authors with practically all of the procedures and methods that are described.

This work is, however, not simply a laboratory manual. Along with the presentation of immunological methods and their applications in the first half of the book, the authors have included sufficient theoretical and background material to constitute a fairly comprehensive exposition of the fundamentals of immunology. Certain topics, such as theories of antibody formation and the role of histamine in allergic reactions, that the authors consider too "controversial" are not discussed to any appreciable extent, but literature references on these subjects are included.

The second half of the book contains explicit directions for various chemical and physical methods that are commonly employed by immunochemists and for the preparation of certain large molecular substances that can now be obtained in relatively pure condition. The methods range from Kjeldahl nitrogen determinations to ultracentrifugal analysis. The biochemical preparations include such materials as crystalline serum albumin, purified antibodies, azo proteins, pneumococcal polysaccharides and blood group antigens that are of interest to immunochemists.

An appendix of 16 pages contains such items as techniques for the injection and bleeding of various laboratory animals and the use of centrifuges and colorimeters. The evident desire of the authors to take very little for granted concerning the background of the reader is well illustrated by their inclusion of directions for cleaning glassware, handling syringes and hypodermic needles, and delivering from pipettes.

Since the book is mainly designed as a practical laboratory guide, it will probably be less subject to the necessity of frequent revision than will more theoretical texts in this fast growing field. An important feature of Kabat and Mayer's book is the emphasis on the use of quantitative chemical methods for the study of antigen-antibody reactions. While such methods have been adopted in very many laboratories, the present work will undoubtedly help greatly to bring them into more general use by immunologists.

ALBERT TYLER

THE BIOCHEMICAL REACTIONS OF CHEMICAL WARFARE AGENTS. *Biochemical Society Symposia Number 2. A Symposium Held at The London School of Hygiene and Tropical Medicine on 13 December 1947.*

Organized and edited by R. T. Williams. The University Press, Cambridge; The University of Chicago Press, Chicago. $1.35 (paper). vi + 73 pp.; ill. 1948.

It is very encouraging to see that a part, at least, of the effort put into chemical warfare problems has produced a really thorough and planned study of the biochemistry of mustard gas and similar substances. This symposium includes the following papers: Chemical Reactions of Mustard Gas in Aqueous Solution (Ogston); Some Reactions of Mustard Gas with Proteins (Boursnell); The Action of Mustard Gas on Enzymes in Vitro and in Tissues (Needham); The Reactions of Arsenicals in Living Tissues (Thompson); Reactions of Lachrymators with Enzymes and Proteins (Dixon); The Reaction of Fluorophosphates with Esterases (Webb); The Pharmacology of Chlorethylamines (Boyland).

L. J. MULLINS

THE BASIS OF CHEMOTHERAPY.

By Thomas S. Work and Elizabeth Work. Interscience Publishers, New York. $6.50. xx + 435 pp. + 1 plate; text ill. 1948.

Occasionally investigators working in a highly specialized field painstakingly provide a summary of the developments in their specialty. This volume is such a review, and workers in the fields of bacterial chemotherapy, pharmacology, or general cell metabolism will be grateful.

The authors have adopted the term "chemotherapy" in its broad sense, including the therapeutic applications of chemical agents. Restriction has been made, however, to the chemical treatment of diseases of microbial origin. The characteristic of this book that appeals most to the reviewer is its skilful blending of chemical theory, bacteriology, biochemistry, enzymology, and cell physiology. As pointed out in the prologue, the aim has been to provide background to each subject sufficient to lure the student of chemotherapy into the study of subjects outside his own original field.

An effort has been made by the authors to focus attention upon the modes of action of drugs rather than upon the possible synthesis of even more compounds of various structures. An attempt has been made to find a rationale for the whole subject based upon what is known. The authors warn that they "provide no royal road to the production of new chemotherapeutic drugs."

The historical introduction includes the classical discoveries of the nineteenth century and a review of the more recent developments. There is a discussion of the mechanism of action of the sulphonamides and the antibiotics. Chapter II is devoted to mechanisms of drug actions via cell metabolism, which is continued in succeeding chapters, entitled Cell Metabolism, Essential Metabolites, Enzyme Inhibition, Drug Antagonism, and Drug Resistance. Chapter VII is concerned with the relation of the structure to the activity of chemical agents, and is broadly conceived. The point is emphasized that factors other than constitutional chemical structure, e.g., the degree of ionization and resonance or mesomeric effect, play a predominant role in determining the pharmacologic effect.

The authors capture the sympathetic interest of the reader by their admission in the Preface that as scientists they are amateur authors, scientific authors with

a limited fund of time and energy available at the end of a full day in the laboratory. The book stands as a monument to their devotion and unfailing energy, and workers in this branch of science everywhere will be grateful.

C. JELLEFF CARR

CONSTITUTION CHIMIQUE ET ACTIVITÉ DES MOLÉCULES THÉRAPEUTIQUES.

By Pierre Laroux. Masson et Cie., Paris. 310 fr. (paper). iv + 118 pp. 1948.

This unusual little book is primarily intended for physicians who are interested in obtaining some insight into the structure of the more important therapeutically active chemicals available in the medical armamentarium. On the assumption that the intended audience remembers little or no organic chemistry, the author has devoted the first third of the book to a refresher course in some fundamentals of structural organic chemistry. Due consideration is given not only to the "backbone" structure (e.g., aliphatic chains and benzene or heterocyclic rings but also to the "functional groups" (e.g., alcohol, thiol, amine, and aldehyde groups). The main portion of the book examines the relation between chemical structure and therapeutic activity, after the usual organization of the subject matter of textbooks of pharmacology: anesthetic agents, hypnotics, analgesics, anti-thyroid compounds, and antihistaminic and antibacterial agents are among the topics discussed.

What makes this work of particular value is the attempt of the author to systematize the subject and to draw, wherever it is feasible, general conclusions regarding the effects of different substituents on the activity of the various drugs considered. While the importance of the physical properties of the drugs and the mechanisms of their action are barely mentioned, and although the discussion of any one group of drugs is of necessity quite limited, nevertheless this book should be of considerable use to those who seek an introduction to the structural aspects of chemotherapy.

FRANCIS CHINARD

BIOCHIMIE MÉDICALE. *Quatrième Édition.*

By Michel Polonovski, P. Boulanger, M. Macheboeuf, J. Roche, and C. Sannié. Masson et Cie., Paris. 1400 fr. (paper). iv + 709 pp.; ill. 1948.

In this, the fourth edition of an extensive and comprehensive textbook of biochemistry written for physicians, the authors have made a considerable effort to include an account of recent work that they consider has some bearing on the practice of medicine. The text, as in the earlier editions, is written in a deliberately didactic style, and the usual topics are covered in considerable detail under the following main headings: Constituents of Living Matter; Chemical Phenomena of Digestion; Tissues, Fluids and Secretions; Intermediary Metabolism; Excretion and Nutritional Exchanges. In spite of the abundant detail, the authors have not integrated the facts presented in such a way as to leave the reader with a better understanding of the relationship of physiological chemistry to clinical medicine. The absence of adequate treatments of pH, oxidation-reduction potentials, acid-base equilibria, osmotic pressure, and other topics of physical chemistry is in large part responsible for this failure. (It may be noted in passing that the same criticisms apply to most textbooks of biochemistry).

As far as it does go, the book is clear, logically arranged, and comprehensive; it just does not go far enough. Finally, although the index is excellent, the absence of an adequate bibliography is unfortunate. Perhaps the authors have presumed that physicians have no time to look up references, even if they are available!

FRANCES CHINARD

EXPOSÉS ANNUELS DE BIOCHIMIE MÉDICALE. *Eighth Series.*

By Z. M. Bacq, A. Boivin, P. Boulanger, A. Delaunay, V. Desreux, M. Florkin, M. Frèrejacque, A. Gadjos, M. Jayle, A. Lacassagne, A. Lespagnol, F. Leuthardt, M. Macheboeuf, Nguyen-Van Thoai, M. Polonovski, J. Roche, Ch. Sannié; edited by Michel Polonovski. Masson et Cie., Paris. 800 fr. (paper). 369 pp. 1948.

One of the services performed by this series of excellent reviews has been to make known to European readers the work published in this country and in England during and after the war. In addition, the reviews bear witness to the fact that there has been considerable activity and achievement in the biochemical laboratories of Europe in spite of the difficulties and sufferings brought about by the war, the years of occupation, and the problems of reconstruction. In general, the articles are informative in nature and present, wherever possible, a critical and integrated picture of some field of biochemistry rather than an impartial listing of all pertinent publications that appeared during a given period. For this reason, the American specialist may be familiar with much of the material discussed here, but the non-specialist will find these reviews of definite benefit in giving him an insight into the problems and achievements of a particular field.

The topics of the more important contributions are: Biological Synthesis of Urea (Leuthardt); Chemical Mediation of Cellular Reactions in Foci of Infection (Boivin and Delaunay); Effects of War Gases on Proteins and Enzymes (Bacq and Desreux); Methionine

(Polonovski and Gadjos); Biogenesis, Intermediary Metabolism and Excretion of Ovarian Hormones (Jayle); Flavoenzymes (Boulanger); Structure of Antibodies (Macheboeuf); Cardiac Glucosides (Sannié and Frèrejacque); and Enzyme Activitors and Inhibitors (Roche and Nguyen-van Thoai). In addition, there are some shorter general discussions by Florkin on metabolic defects, by Lacassagne regarding possible mechanisms of action of carcinogenic hydrocarbons, and by Lespagnol on the relation of chemical structure to pharmacological activity. These reviews represent a definite contribution to biochemical literature and it is to be hoped that they will have the wide circulation they deserve.

FRANCIS CHINARD

EXPOSÉS ANNUELS DE BIOCHIMIE MÉDICALE. *Ninth Series.*

By P. Balâtre, J. Boer, P. Boulanger, L. Bugnard, J. Courtois, M. Dubuisson, P. Fleury, R. Michel, J. Roche, and C. Sannié; edited by Michel Polonovski. Masson et Cie., Paris. 1000 fr. (paper). iv + 319 pp. + 4 plates; text ill. 1948.

The ninth volume of this series maintains the high standards set by the earlier ones and contains several articles which should be of interest to biologists. The first review is by M. Dubuisson on the proteins of muscles. While there have been several recent publications in this country bearing on this problem (see the New York Academy of Sciences Symposium, *Muscular Contraction*, reviewed Q. R. B. 23: 374; and Szent-Györgyi's *Chemistry of Muscular Contraction*, reviewed Q. R. B. 23: 75), the present review emphasizes the preparation of the muscle proteins and their physico-chemical properties. It should be of particular interest to American workers in this field because of the description of the findings of the Belgian school on the electrophoretic patterns of muscle proteins under various conditions.

In another article, on periodic acid, Courtois presents a very complete description of the periodate reaction, its specificity, and its application to many problems of biological importance. This article will be of considerable value to users of the reaction. Also noteworthy are Sannié's review of the chemistry and physiology of the saponins, and Roche and Michel's article on the iodinated proteins of the thyroid, chemically iodinated proteins, and the mechanism of the formation of thyroxin.

Other contributions are Boulanger's on mitotic poisons, Fleury and Balâtre's summary of Fleury's monograph on inositol, and Bugnard's on the use of stable isotopes in biology. Finally, there is a progress report by Boer on a new rat growth factor, found in summer butter, which may or may not be related to vaccenic acid.

FRANCIS CHINARD

AN INTRODUCTION TO CHEMICAL SCIENCE. *Second Edition.*

By W. H. Hatcher. John Wiley & Sons, New York; Chapman & Hall, London. $4.00. x + 449 pp.; ill. 1949.

It is difficult to say just what sort of an approach to chemistry one should offer to students who are pursuing courses in the liberal arts. An historical approach is tempting. In the present volume, however, one finds a highly condensed summary of inorganic and organic chemistry, together with a section on nutrition and industrial chemistry. The result is not very interesting to read, although it does cover rather systematically a great deal of physics, chemistry, and biology. The treatment seems to be more suited to a high school than to a college level.

On his biological excursions, the author makes some rather misleading statements. In mentioning the use of low concentrations of CO_2 with O_2 in resuscitation, he has stated that CO_2 "acts as a stimulant to the lungs to increase their absorption of the necessary oxygen." In connection with photosynthesis, plants and animals are treated as though plant metabolism were concerned only with using the CO_2 produced by animals and giving off O_2 for animals. Readers will not be pleased to learn that "a diameter of 1 micromicron (10^{-12} meter) is regarded as the upper limit of size for molecules; the hydrogen molecule is 0.1 micromicron." In addition to a number of factual inaccuracies, this second edition contains quite a few typographical errors.

L. J. MULLINS

PRE-MEDICAL PHYSICAL CHEMISTRY.

By F. A. Matsen, Jack Myers, and Norman Hackerman. The Macmillan Company, New York. $4.75. viii + 344 pp.; ill. 1949.

A collaboration between a biologist, a chemist, and a physicist has produced this eminently readable little volume, which is well suited not only to the needs of pre-medical students but also to those of biologists who lack formal physics training. The authors' approach to the subject is one of using biological applications to illustrate physico-chemical principles. Thus applications of the gas laws are discussed in terms of respiration measurements with the Warburg apparatus, and gas tension theory is related to the Van Slyke apparatus. A mathematical introduction presents simply

certain elementary aspects of the differential calculus necessary to understand reaction kinetics.

As the authors have remarked, their choice of subjects has had to be rather arbitrary. While one might wish for some treatment of photochemistry and perhaps for some expansion of the material on the magnetic properties of molecules, the selection of topics is in general very commendable. This is not a book for the research worker, and indeed some may find that since it gives one little appreciation of the general theoretical foundation of physical chemistry, it is undesirable. On the whole, such a disadvantage would seem to be outweighed by the advantages of giving the student a good working knowledge of a large number of physico-chemical principles.

LORIN J. MULLINS

RAPID MICROCHEMICAL METHODS FOR BLOOD AND CSF EXAMINATIONS.

By F. Rappaport; with a foreword by F. Silberstein. Grune & Stratton, New York. $8.75. xviii + 404 pp.; ill. 1949.

This is a concise clinical laboratory manual which covers adequately all the common laboratory tests ordinarily required for blood and cerebrospinal fluid analyses. Many of the procedures are quite ingenious when considered as improvisations, since the author had the difficult task of setting up clinical laboratories in Palestine during the war, and many of the common laboratory supplies were not available there.

The book suffers to some extent from typographical errors in the text and in the title on the binding. The style is rather hard to read, owing presumably, to the author's unfamilarity with English. The methods are in many cases not microchemical, in the research sense of the word, and there is no mention of such apparatus as the Conway micro-diffusion cell, modern microburettes and micropipettes, or the density gradient columns of the Carlsberg type. The author explains in his preface that one of the aims of the book was to work out methods using simple apparatus, and for this reason expensive apparatus such as photo-electric colorimeters are merely mentioned. With this reservation in mind, the book can be recommended to those who need laboratory methods requiring only the simplest of apparatus.

L. J. MULLINS

MICROBIOLOGY

ANNUAL REVIEW OF MICROBIOLOGY. *Volume II. Edited by Charles E. Clifton, Sidney Raffel and H. Albert Barker. Annual Reviews, Stanford, California.* $6.00. viii + 532 pp.; ill. 1948.

The second volume of this new series contains 18 reviews, more or less evenly divided between the compilatory and the critical. In the former category, there are excellent summaries of recent work on bacterial metabolism (Gunsalus) and antibiotics (Bailey and Cavallito). Outstanding among the critical reviews are the articles on the mode of action of chemotherapeutic agents (Hotchkiss) and on yeasts (Mrak and Phaff), although the latter is marred by an apparent complete absence of proof-reading. There are one or two reviews that fail to meet acceptable scientific standards; in particular, Lindegren's article on the genetics of the fungi presents a misleading and inadequate picture of this important subject.

With a scientific field as broad and hazy about the edges as microbiology, one can hardly expect complete coverage of the annual literature in a volume of 500 pages. However, the reviewer is left with the impression that the editorial board could have made better use of the space available by broadening many of the topics covered. Extreme specialization of subject matter is particularly noticeable in the subjects of medical interest. For example, 20 pages have been devoted to a review on the metabolism of malarial parasites (Moulder), as against 30 pages to the entire field of bacterial metabolism. The justification for such an allotment is dubious, particularly since little really novel biochemical information appears to have emerged from the recent researches on malarial parasites. Other examples of the same trend toward specialization of material are to be found in the articles on complement (Ecker) and on pathogenic streptococci (Rammelkamp and Dingle), both of which subjects could certainly have been treated adequately in a much wider framework.

R. Y. STANIER

THE FILTERABLE VIRUSES. *Supplement Number 2, Bergey's Manual of Determinative Bacteriology, Edition VI.*

By Francis O. Holmes. The Williams & Wilkins Company, Baltimore. $2.50. iv + pp. 1127–1286 + xxiii pp. 1948.

The classification of viruses published in the sixth edition of Bergey's *Manual of Determinative Bacteriology* is reprinted separately in this volume and constitutes an important reference book for specialists in virology or infectious diseases. Members of the Order Virales are classified in three groups: the bacteriophages (Phagineae), viruses causing diseases of higher plants (Phytophagineae), and those which infect animals (Zoophagineae). The 13 families, 32 genera, and 248 species are delineated on the basis of size,

morphology, host, serological and immunological relationships, transmission, pathogenicity, and other properties. Readers of the *Quarterly Review of Biology* who are not students of virology may be interested in knowing the specific names of the etiological agents of some of the common virus diseases: e.g., the cause of measles is *Briareus morbillorum;* of poliomyelitis, *Legio debilitans;* of rabies, *Formido inexorabilis;* of yellow fever, *Charon evagatus;* and the causative agent of influenza A is *Tarpeia alpha.*

HARRIETTE D. VERA

INTRODUCTION TO MICROORGANISMS. *Second Edition. By LaVerne Ruth Thompson. W. B. Saunders Company, Philadelphia and London.* $4.25. xii + 454 pp.; ill. 1949.

TEACHER'S GUIDE FOR USE WITH INTRODUCTION TO MICROORGANISMS. *Second Edition. By LaVerne Ruth Thompson. W. B. Saunders Company, Philadelphia and London.* Paper. 43 pp.

This is a good elementary textbook on the public health aspects of microbiology, the first edition of which was reviewed in this journal (Q. R. B. 19: 348. 1944). The new is an up-to-date version of the earlier edition, and is designed for use by students who have little scientific background. The five units of the text are Life in Miniature, Bacteria and the Environment, Parasites and the Host, the Pathogens, and Man against Parasites. "Laboratory Experience" is suggested after each of the first four units. Supplementary reading lists are given at the ends of the chapters.

A brief guide for teachers in schools of nursing has been written to accompany the textbook. It contains some excellent suggestions for teaching, and considerable practical information, which ought to be particularly helpful to inexperienced teachers. There are, for example, lists of supply houses and of films and their distributors.

HARRIETTE D. VERA

BACTERIAL METABOLISM. *Third Edition. By Marjory Stephenson. Longmans, Green and Company, New York, London and Toronto.* $7.50. xiv + 398 pp. + 1 plate; text ill. 1949.

The late Miss Stephenson's *Bacterial Metabolism* has been an indispensable book in the microbiologist's library for twenty years and, in spite of the criticisms expressed below, it still remains by far the best presentation of the subject. The present revision is in many respects disappointing. To accomodate comfortably the facts and concepts that have emerged in the decade since the previous edition, a complete reorganization of the material was required. Instead, the framework of 1939 has been preserved intact, and new information has been inserted piecemeal. The result is a lack of integration so great as to obscure many important principles. For example, the essential differences between respiration and fermentation, never too clearly defined in previous editions, are now even less adequately presented. This is evidenced by the fact that two typical fermentations are discussed in the chapter on respiration, while the respiratory processes of acetic acid bacteria remain as part of the material on fermentation. The same lack of integration is apparent in the treatment of biosynthetic mechanisms. The growing mass of information on the synthesis of amino-acids and vitamins certainly justifies coherent presentation, yet one finds this material scattered over several chapters.

Although the revision was completed in 1947, many important papers published prior to that time have been overlooked. Omissions are most serious in the chapter on enzymatic variation and adaptation, where the author has failed to consider the implications of recent work on bacterial genetics and on adaptive enzyme formation.

R. Y. STANIER

MICROORGANISMES DE NOS EAUX DOUCES. *Sciences et Médecine. Série des Sciences Naturelles. By Charles de Wyngaert. F. Rouge & Cie., Lausanne.* 7.50 fr. (paper). 163 pp. + 11 plates; text ill. 1947.

Aiming to draw the attention of the public to the less obvious living things no farther distant than the local rain barrel or pond, the author introduces his readers first to Leeuwenhoek, and then to unicellular animals and plants, bacteria, algae, and fungi on the one hand, to rotifers, worms, and small arthropods on the other. The ecological interrelationships receive some attention, particularly in a general chapter on fresh-water plankton. There is an adequate bibliography and an index.

LORUS J. & MARGERY J. MILNE

HEALTH AND DISEASE

MEDICINE ON THE MARCH. *A Progress Report. A Newsweek Book. By Marguerite Clark. Funk & Wagnalls Company, New York.* $3.50. x + 308 pp. 1949.

A great deal of information is presented here on a variety of timely and important subjects. The chapter headings include heart disease, cancer, psychiatry, allergy, new drugs, and health in old age. Much recent research is reviewed with skill, conviction, and style.

The significance of some of the findings discussed here probably needs the evaluation of future experience. From the cautious scientist's point of view, there is occasionally an impression of undue dramatiza-

tion and over-optimism, for even very encouraging results found in early experiments do not always solve problems.

The book is designed for reading by the general public, and has merit in that it explains many terms which have not yet reached the household dictionary. Also, it is a popular report, within one small volume, of an enormous amount of scientific investigation.

HARRIETTE D. VERA

PUBLIC HEALTH STATISTICS. *Second Edition.*
By Marguerite F. Hall. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York. $7.50. xxx + 441 pp. + 1 chart; text ill. 1949.

The first edition of this book (1942) was reviewed in this journal, Q. R. B. 19: 71, 1944. It was pointed out then that the book could not be recommended because of its numerous errors of fact in citing source material, as well as errors of definitions, theory, and application. It was hoped that the second edition would represent a complete rewriting, but unfortunately the revision has been only slight, and the errors of the first edition are almost wholly conserved. Of the nine errors cited as illustrations in the previous review, not one has been corrected. One, indeed, has been omitted, due to the deletion of the particular discussion in which it occurred. The appearance of this sort of a second edition is to be regretted.

MARGARET MERRELL

BIOLOGY OF DISEASE. *Mt. Sinai Hospital Monograph Number 1.*
By Eli Moschcowitz. Grune & Stratton, New York. $4.50. viii + 221 pp.; ill. 1948.

Biology of Disease is a series of essays on selected diseases. Instead of orthodox differentiation for study and clarification, Moschcowitz believes that a similar pathogenesis indicates intimate biologic relationship, and he utilizes it for the study of chronic diseases of unknown etiology.

Moschcowitz claims that pulmonary hypertension is always the underlying cause of pulmonary arteriosclerosis, and although the hypertension may be brought about by a variety of totally unrelated conditions—the end-results are similar. These are therefore discussed as an entity. Similarly, in the second essay, the many causes of systemic hypertension are listed, but the results of hypertension are discussed from the viewpoint of biological evolution. Arteriosclerosis is considered by Moschcowitz to be a gradual evolution resulting from physiological aging, and he stresses the lack of differentiation between the two conditions. This is interesting philosophically, but it fails to evaluate the role of possible agents in the pathogenesis of the disease.

A discussion of "Libman-Sacks" disease traces its various manifestations chronologically in a fairly simplified manner. On the other hand, the chronological unfolding of the phases and possible "mutations" of polycythemia vera, follicular lymphoblastoma, and leukemia complicates the understanding of these conditions unnecessarily. The reviewer must disagree with the concept that this method of study is more helpful than the conventional differential diagnosis into distinct entities.

The "biologic" analysis of antecedent events and sequelae is most successful in Moschcowitz's study of cirrhosis of the liver, obesity, glomerulonephritis, nephrosis, and uremia. Graves' disease and peptic ulcers occupy interesting chapters, too, but these subjects suffer from excessive repetition and reanalysis in the chapters on psychosomatic and hyperkinetic diseases. The biologic relation between achlorhydria, anemia, and the sprue syndrome is instructive, although not completely up-to-date. In other chapters, the biological method of study throws little light upon such subjects as myeloma, toxic hepatitis, and emphysema, each of which can be better studied in an orthodox system of medicine or pathology textbook. These essays at most forward the author's intention to "stimulate a point of view and a methodology rather than to be strictly informative."

ELLA H. OPPENHEIMER

PATHOLOGY.
Edited by W. A. D. Anderson. The C. V. Mosby Company, St. Louis. $15.00. xii + 1453 pp. + 10 plates; text ill. 1948.

This new textbook of pathology is a large volume of 1453 pages, edited by W. A. D. Anderson but written by no less than 32 experts in specific fields. Thus, although every aspect of pathology has been included, interrelationships between subjects are frequently lost because of the lack of a unified point of view. Some of the collaborators emphasize pathogenesis and experimental work in surveying their fields, and this proves interesting and helpful. Other contributors, however, give only dogmatic descriptions of pathological changes.

A bibliography follows each chapter. These bibliographies also suffer from lack of uniformity and, therefore, impaired usefulness. Some contributors indicate the subject matter in the bibliography by numbered references in the text; others list titles or describe subjects for each reference. Another group of contributors, unfortunately, lists their references under general subjects only, thereby limiting their value.

The text is divided into two parts. There are 20 chapters on the general aspects of pathology, including

an introductory chapter, and a chapter on heredity and constitution in disease. Twenty-six chapters are devoted to specific pathology, that is, to the specific changes peculiar to particular organs and tissues. This is now the conventional pattern for pathology textbooks, but it produces quite unnecessary repetition. Furthermore, to stress the isolated pathological changes that occur in specific tissues diminishes one's appreciation of those overall general bodily changes in disease which constitute so important a fundamental pathological basis for the understanding of clinical medicine.

Many subjects not found in other textbooks of pathology are included here. There are chapters on tropical medicine, and on the effects of radiation; and more than the usual space is allotted to diseases of the skin, special senses, nervous and skeletal systems. The descriptions of gross, microscopic, and experimental pathology are well augmented by a profusion of excellent illustrations. In addition to the numerous photographs, there are valuable diagrams and 10 colored plates.

In respect to comprehensiveness, this volume must be given an A1 rating as a pathology textbook. Yet it will probably prove more valuable to the advanced student of pathology or as a reference book for physicians, than to the elementary student of pathology, who in discouragement because of its very size and completeness might be led to seek a more modest textbook.

ELLA H. OPPENHEIMER

YOUR COUGHS, COLDS AND WHEEZES.

By Joseph D. Wassersug. Wilfred Funk, New York. $2.95. x + 277 pp. 1949.

There ought to be more books like this one. Its author is to be commended for achieving a realistic and intelligent presentation of much factual information in an interesting and lively manner. The approach is neither defeatist nor exaggeratedly optimistic; it is rational and practical. The book is both *designed and written* for the general reader. And its readers should be numerous, since all readers are likely to have plenty of personal experience with coughs and colds and wheezes. Actually, the text covers the present status of knowledge of colds, the cigarette cough, influenza, pneumonias, asthma, tuberculosis, tumors, and other pathologic conditions; and also such problems as industrial hazards and the costs of respiratory illness. A short quiz (with the answers) is appended to each chapter.

HARRIETTE D. VERA

THE PATHOLOGIC PHYSIOLOGY OF UREMIA IN CHRONIC BRIGHT'S DISEASE. *A Monograph in American Lectures in Physiology. American Lecture Series, Publication Number 15.*

By Stanley E. Bradley. Charles C. Thomas, Springfield, Illinois. $2.00. vi + 69 pp.; ill. 1948.

This monograph reviews the altered physiology of the body in uremia caused by chronic diseases of the kidney. The author describes normal renal functions, as well as urinary and plasma findings as a basis for comparison with the changes in uremia. Numerous charts illustrate graphically many of the more complicated results of renal insufficiency. Finally, the clinical symptoms in uremia are correlated with renal dysfunction and secondary faulty systemic physiology. A bibliography of 128 references covers every aspect of this complicated subject.

ELLA H. OPPENHEIMER

ON THE GENESIS OF "OSTEITIS FIBROSA GENERALISATA" (ENGEL-RECKLINGHAUSEN DISEASE). *Acta Pathologica et Microbiologica Scandinavica, Volume XXIII, Fasc. 1.*

By Åke Wilton. Einar Munksgaard, København. Dan. Cr. 8.00 (paper). 51 pp.; ill. 1946.

Three cases studied, all occurring in females, manifested the same type of hyperparathyroidism associated with osteitis fibrosa. The disease was intermittent in character, was in each case marked by onset at pregnancy and by increased severity during additional pregnancies or menopause and was also in each case accompanied by extensive histological changes in the pituitary. The condition is probably due to an upset endocrine interrelationship between the pituitary and the ovaries, rather than to an autonomous disorder of the parathyroids. This disease is not to be confused with neurofibromatosis (Recklinghausen's disease), which is inherited as a simple dominant trait. No suggestion that osteitis fibrosis is hereditary is made by Wilton.

ANIMAL PATHOLOGY. *Fourth Edition.*

By Russell A. Runnells. The Iowa State College Press, Ames. $7.00. xiv + 639 pp. + 4 plates; text ill. 1946.

With this new edition, Runnell's *Animal Pathology* has been brought up to date. It is the only American textbook of animal pathology, and presents the American point of view. The author has made a complete survey of current veterinary and medical literature in preparing this revision. Of its three parts, the first deals with General Pathology. This includes discussions of predisposing factors of diseases and causes, disturbances in development, circulation, nutrition, and cell metabolism, death, defenses of the body against injury, concretions, and tumors. The second part is

entitled Systemic Pathology. This part covers the pathology of all the systems of the body very thoroughly. The third part is on the Special Pathology of Specific Infectious Diseases. Included in this part are brucellosis, pasteurellosis, anthrax, actinomycosis, erysipelas, tuberculosis, glanders, streptococcic and clostridial diseases, virus diseases, and various other infectious diseases. Also included here is a new chapter entitled Avian Leukosis Complex, and describing the different types of this disease and its pathology.

The illustrations are numerous and well chosen, making it an excellent book for a student of pathology as well as a good reference book in the fundamentals of pathology for the scientist. Extensive lists of references are included.

FRANCIS L. EARL

PRINCIPLES OF VETERINARY SCIENCE. *Fourth Edition.* *By Frederick Brown Hadley. W. B. Saunders Company, Philadelphia and London.* $5.00. xii + 521 pp.; ill. 1949.

This new edition has brought Hadley's book up to date in its treatment of the rapidly expanding field of veterinary medicine. The book was originally written as a textbook for teaching the principles of veterinary science to agricultural and preveterinary students in agricultural colleges, its value being to serve as an introduction to further study of the field. The author has preserved this aim in making the revision.

The book is composed of two parts. The first covers the anatomy and physiology of the animal. The Introduction briefly explains the functions of veterinary science and its place in the animal field as well as in the scientific field and its relationship to medicine. A very brief history of medicine, veterinary medicine, and veterinary education is given with due regard for all the specialized fields of work, including military veterinary medicine. A new chapter, The Animal World, gives the main subdivisions of the animal kingdom and some explanation of each. These are well defined as to type and to function, if any, in our environment. The animal body as a whole is covered in some detail both as to the histology and the physiology of all structures from protoplasm to organs and systems. Each system of the body is so described, both anatomically and physiologically, that no essential detail is omitted and, yet, in a manner simple enough to be understood by the beginner in scientific studies. All terms are well defined.

The second part of the book covers the animal diseases. All common diseases, both communicable and non-communicable, are described as to cause, symptoms, and treatment and prevention, if any. A new chapter, Veterinary Hygiene, has been added to this part. All phases of veterinary medicine are discussed, including medicines, pathology, hygiene, wounds, nutrition, surgery, obstetrics, parasitology, poisons, and physiological disturbances.

In this edition, special emphasis has been placed on the diseases of cattle. Conditions in horses have either been omitted or are covered quite briefly.

FRANCIS L. EARL

IDENTIFICATION OF TUMORS. *Essential Gross and Microscopic Pathologic Features Systematically Arranged for Easier Identification.*

By N. Chandler Foot. J. B. Lippincott Company, Philadelphia, London, and Montreal. $7.00. xxii + 397 pp.; ill. 1948.

This volume should prove indispensable to the surgical pathologist and pathologist. The rapid identification of tumors has been made possible by Foot in the same way birds, butterflies, or flowers, are identified by the naturalist with the aid of a pocket guide. This book does not pretend to give a comprehensive discussion of any one tumor. Instead, it fills the role of a "ready reference book" for the classification of virtually every sort of tumor which has been described in the medical literature.

Tumors are classified here according to their origin. One part is devoted to those tumors that arise from general tissues; another portion describes the tumors arising from specific organs. There is an excellent differential diagnosis distinguishing the benign and malignant analogues of every variety, and each tumor has an excellent illustration and adequate description of its microscopic appearance. Pertinent clinical data and gross appearance are given briefly.

Foot concludes this volume with technical methods for differential diagnosis, and gives complete directions for the fixation and staining of tumors. Special stains that are helpful for diagnosis are suggested. Finally, there is appended a tabular locator for identifying neoplasms of general distribution and also for tumors arising from virtually every site in the body.

ELLA H. OPPENHEIMER

DIAGNOSIS AND TREATMENT OF MENSTRUAL DISORDERS AND STERILITY. *Second Edition.*

By Charles Mazer and S. Leon Israel. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York and London. $7.50. xiv + 570 pp. + 2 plates; text ill. 1947.

This is the second and revised edition of a highly regarded book on a very circumscribed field of medicine. The authors bring good clinical equipment to their task, since they have long pioneered in the development of certain types of treatment for these disorders.

The first quarter of the book is devoted to the physiology of the reproductive tract, particularly the hor-

monal aspects. In practical fashion, the authors list and compare the potency of the confusing multitude of hormone preparations, each individually named by the drug house promoting it. They also state which hormones create antihormones and consider the therapeutic suggestions resulting from this knowledge. The last three quarters of the book deal with the practical application of the basic physiology. If the reviewer may be critical at all, he would criticize the generally commendable optimism of the authors, a necessary measure of sanity for those who work in so pessimistic a discipline as the study and treatment of human sterility. For example, in evaluating the effects of various hormone preparations on the subnormal semina of their 167 male patients, Mazer and Israel write in terms of what is accomplished in raising the sperm count, and do not indicate how many patients as a result were enabled to father their own children. However, in a later chapter they do tally their personal score in the treatment of 459 selected barren couples that included thirty men with inadequate semen. Two hundred and sixty-one pregnancies were achieved in these families, a truly remarkable result. Mazer and Israel have written a valuable book, safe in the hands of the expert. I fear, however, that if the average physician uses it as his "bible" for dealing with problems of sterility, it may lead to overtreatment.

ALAN F. GUTTMACHER

FETAL AND NEONATAL DEATH. *A Survey of the Incidence, Etiology, and Anatomic Manifestations of the Conditions Producing Death of the Fetus in Utero and the Infant in the Early Days of Life. Second Edition.*

By Edith L. Potter and Fred L. Adair. The University of Chicago Press, Chicago. $3.75. xiv + 173 pp.; ill. 1949.

It is a pleasure to report the publication of the revised edition of this little book, which has been brought up to date to include the results of work done during the past decade as well as up to the minute statistics. The book contains a chapter on the development and growth and the anatomy of the normal fetus and infant, a detailed description of the recommended procedures for post mortem examination, and a discussion of general and special pathology of the fetal and neonatal period. The book is recommended to all who have opportunity to perform autopsies on newborn infants. Since the total number of stillbirths and deaths during the first week of life in the United States exceeded 140,000 in 1946, this would seem to be a major field for research and action in preventive medicine.

CHRISTOPHER TIETZE

PROGRESS IN GYNECOLOGY.

Edited by Joe V. Meigs and Somers H. Sturgis Grune & Stratton, New York. $7.50. xiv + 552 pp. + 1 plate; text ill. 1946.

This summary of recent advances in the field of gynecology is written for the undergraduate as well as the post-graduate medical student. Its list of seventy contributions reads like a Who's Who in American Medicine. No critic could in least suspect the authority of the words of any. The essays vary from three to twenty pages in length.

The contents are arranged in ten sections: Growth and Physiology; Diagnostic Methods; Functional Disorders; Interrelationship of Endocrine Glands; Sterility and Reproduction; Infections and their Treatment; Benign Growths; Malignant Growths; Operative Technique; and Preoperative and Postoperative Care.

As proper in a current treatise of gynecology, there is weighted emphasis on the endocrines, for this is the particular phase of the science which has recently made most progress. The present edition just antedates the isotope researches, and one may hazard a guess that in the next edition—and *Progress in Gynecology* deserves several in the years to come—the isotopes will occupy many pages. It is to be hoped that the authors will keep the book sufficiently fluid so that it will always justify its title as much as it does now.

ALAN F. GUTTMACHER

A TEXTBOOK OF GYNECOLOGY. *Fifth Edition.*

By Arthur Hale Curtis. W. B. Saunders Company, Philadelphia and London. $8.00. xvi + 755 pp.; ill. 1946.

This standard textbook, first issued in 1930, has been extensively revised by the author. It is well printed and the text has been strengthened by 450 drawings and microphotographs. The Curtis textbook is primarily a practical volume, obviously written by a man with a wide clinical experience. We have no hesitancy in recommending it to the gynecologist and medical student alike; each will profit by adding it to his library.

ALAN F. GUTTMACHER

THE ESSENTIALS OF OBSTETRICS AND GYNECOLOGY.

By William Albert Scott and H. Brookfield Van Wyck. Lea & Febiger, Philadelphia. $5.50. 390 pp.; ill. 1946.

This is a concise exposition of obstetrics and gynecology as practiced by the excellent Toronto School of medicine. It is more of an outline than a full-fledged textbook in the American sense; for example, only one and

a half pages are devoted to the complicated topic of multiple pregnancy. The reviewer was delighted, however, to see a chapter on contraception, a topic generally omitted. There is no bibliographic reference in the whole volume, and I fear that after reading *The Essentials of Obstetrics and Gynecology*, the student will gain the unintended idea that these sciences are static rather than highly fluid. It is the opinion of the reviewer that a textbook has a threefold purpose: to present the best in present-day knowledge, to tell the reader where he may pursue further a topic of special interest, and to stimulate research by indicating the unsolved riddles. Scott and Van Wyck do an adequate job with the first of these and utterly exclude the two latter.

ALAN F. GUTTMACHER

PSYCHOLOGY AND ANIMAL BEHAVIOR

PSYCHOLOGY APPLIED.

By George W. Crane. Hopkins Syndicate, Chicago. $4.00. 680 pp.; ill. 1948.

The fact that this textbook is now in its thirteenth printing should be ample evidence of its popularity. Your reviewer is frankly puzzled by this, but who is he to question history? The main trouble with the present version is that it shows its age badly. Most of the illustrations refer to events and people who, I'll wager, are completely unknown to this generation of students. As one example of how out of date the book is, the author reproduces an advertisement which asserts, "With that $3 you save on your tooth paste, . . . buy 30 loaves of bread." Another advertisement shows men's white shirts for sale at $1.09!

There are other more serious criticisms one can level against the book. Somewhat less than 10 per cent of all the items in the bibliography refer to literature dated since 1940. At that, it is hard to avoid the feeling that most of the newer citations were thrown in hastily for the sake of appearance. They are never referred to in the text, and they appear in odd contexts.

On the whole, the book is not well organized. For example, in the middle of a section labelled "The Qualifications of a Good Teacher" in Chapter 14, the author announces, "At this point it would be well to mention a few statistical terms." Without setting this material apart in any way, he then goes on to discuss the mean, median, standard deviation, product-moment correlation, and other statistics for four pages. At the conclusion of this weird digression he continues his resumé of the qualifications of a good teacher! Needless to say, statistics are used in the book long before Chapter 14.

The contents, too, constitute an amazing pot-pourri. You will find here a nine-page description of how to treat acne, complete with illustrations of a blackhead extractor. And if you want to know how to "confound and confute any cynicism or sarcasm that a smart aleck Ph.D. may attempt in his efforts to undermine your children's firm religious anchorage," just turn to Dr. Crane's handy little book for a five-page "logical proof of God."

If you want to learn about applied psychology, it may be suggested that you consult some other book.

A. CHAPANIS

COLOR AND PERSONALITY.

By Audrey Kargere. Philosophical Library, New York. $3.50. xviii + 134 pp. 1949.

Purporting to be a treatise on the "psychological effects of color," this volume is a hodgepodge of lore drawn from phrenology, mesmerism, Zoroastrianism, and the modern pseudo-medicine of "Chromotherapy." A few poems are included to accent the emotional tone with which it is written. The reviewer is unable to locate any evidence of controlled verification of the sweeping statements the book includes. Sample items: the large number of kidney disorders of the last generation was due to the widespread use of the color red in flannel underwear, red light being inimical to the kidneys (p. 69); only 20 per cent of the light striking the eye is used for seeing—the other 80 per cent is utilized in recharging (sic) the nervous system (p. 16); a trained observer can see the colors of thoughts radiating from a thinker, which are of a fibrous, vaporous appearance (p. 43); it is silly to think that a color is ineffective if it is in the dark (p. 105). The reviewer shudders to think of the destruction such a book as this might wreak upon the prestige of honest scientific students of color, were it to attain any sizeable circulation.

HOWARD D. BAKER

CHALLENGE OF THE UNKNOWN: *Exploring the Psychic World.*

By Louis K. Anspacher, with an introduction by Waldemar Kaempffert. Current Books, A. A. Wyn, New York. $3.75. 327 pp. 1947.

In this volume the writer has presented a variety of material as evidence for the reality of personality functioning beyond the limits of the physical organism. Included are, as might be expected, anecdotes galore of such phenomena as prophecy, telepathic communication, materialization and emergence of phantasms, clairvoyance, and horse behavior more intelligent than human behavior. There are references to laboratory investigations of extra-sensory perception. There is a section entitled Psychic Manifestations in Art and Literature, in which we find that "art gives eloquent

corroboration, in terms of beauty, to the existence of a world beyond the prudent, cautious mediocrity of our common senses" (p. 135), and that "... great art testifies to a vague but genuine consciousness of a supersensuous and a spiritual environment, and another dimension of life to which the creative psyche has access" (p. 138). There is a catalog of quotations from innumerable philosophers, Heraclitus to the present, carefully edited and annotated so to give powerful testimony to the existence of the psyche. And finally we discover here that the Bible is meaningful only if it is accepted as a psychic document; that true prayer is a form of telepathy; that "... religious genius possesses every hallmark of the psychic sensitive" (p. 281); and that the life and work of Jesus can be completely understood and appreciated only if we accept him as "the most powerful medium and perhaps the greatest psychic sensitive" in history (p. 296). On the one hand is the blind and bewildered fumbling of traditional science, of physics as well as psychology, in a universe whose mysteries are far beyond the grasp of scientific procedure. On the other hand, fortunately, stands psychic research, which is ultimately to furnish the basis for illuminating these mysteries.

As an integrative synthesis of many lines of thought to document an already accepted viewpoint, this is an outstanding piece of work. But as a reasoned argument to convert the doubter, it is marked by certain flaws. The very skill of rhetoric that confirms the believer may strike the skeptic as the most blatant manipulation of devices of propaganda. There is no compromise between black and white in Anspacher's choice of terms: the supporting evidence is irrefutable, incontrovertible, overwhelming, inescapable, the result of meticulous, scrupulous, sensitive, highly objective and scientific observation by faithful, sober, and incorruptible experts of great experience, humility, high courage, and profound scientific probity. Contradictory opinion is dismissed as utterly wrong, the grand talk of dogmatic Bourbons (or Pharisees and Philistines), those pompous oracles who limp along on the facile crutches of skepticism, mocking and sneering, committing scientific hara-kiri with their deplorable prejudice and fanaticism, their authoritative ignorance, their cowardly evasion. Then, too, it is difficult to judge where the author's data end and his interpretations begin, to distinguish between observation and inference. He "knows" many things which the present-day psychologist feels able to deal with only in tentative hypothesis, if at all—a discrepancy which may somehow be allied with the absence of American experimental psychologists from the line-up of scientists who allegedly attest the correctness of the psychic position. Anspacher can recognize the distorting influence of wishful thinking, emotionality, and suggestibility in the opposition of the scoffers, but he neglects to take these factors into account when quoting statements favorable to his views. In short, one might be tempted to conclude either that there are a number of unconscious blind spots in Anspacher's wide vision, or that he has deliberately stacked the cards for the sake of polemic.

There is truly much that is unknown to man, and the unknown is always challenging. The juxtaposition of material from many disciplines may often be the logical beginning to meeting the challenge. But such a compilation will probably be fruitful only to the extent that it describes the status of each of the disciplines with reasonable accuracy and emotional detachment, clearly indicating where intuition attempts to jump the gap. *Challenge of the Unknown* must be indicted for failure on this count.

FRANK W. FINGER

EMOTIONAL MATURITY. *The Development and Dynamics of Personality.*

By Leon J. Saul. J. B. Lippincott Company, Philadelphia, London, and Montreal. $5.00. xii + 338 pp.; ill. 1947.

In this volume, the author has attempted a well rounded discussion of the development of personality and its non-psychotic disorders. The viewpoint of the author is based upon many of the fundamental concepts of psychoanalysis, but it is not psychoanalytic. He draws upon experiences in the army for the discussion of the factors in the development of emotional maturity, but rather than making the book one in military psychiatry, he uses such illustrations for their contribution to the general point of view he takes.

The author first describes emotional development in general terms, and then various aspects of it in more detail. His primary theme is the achievement of independence out of the infantile dependent state. Closely allied themes are the loss of egocentrism, the handling of hostility and aggression, and the development of realism. These are well described and illustrated.

In the third section of the book, the author discusses the various patterns of maladjustment, not in the usual psychiatric terminology but in terms of the previously developed themes leading to emotional maturity. A final section is a theoretical and conceptual summary of the nature of personality.

The book is to be recommended to the general reader. Without sacrificing accuracy and necessary complexity, it communicates the important ideas of personality development in a non-technical fashion. There are numerous points where various theoretical points of view differ from the author's conceptualizations, but probably there would be a consensus that he has described in a realistic way the phenomena of personality development and that he has contributed to the understanding of them.

ALFRED L. BALDWIN

MY DEAR EGO. *A Look in the Mirror.*

By Fritz Kunkel, with line drawings by Janet Smalley. The Pilgrim Press, Boston. $2.50. x + 147 pp.; ill. 1947.

This small book is addressed to young people and adolescents, and is intended for use in self-guidance and for help in understanding some of the common problems of adolescence and heterosexual relationships. The point of view expressed is, of course, characteristically Kunkel's, as set forth in his previous books.

As such books go, this one is well done. College students to whom the reviewer has given it have thought it amusing and instructive. The first part, dealing with the general description of personality and personal relations, seems particularly well written. The second section, which discusses the relationship between boys and girls, is less likely to be effective. A ten-year plan for preparing to get married, which the reader is invited to undertake, seems unlikely to be received sympathetically by an adolescent reader even though it may have much of value in it.

One's main feeling about the book is that such an attempt to use an intellectual medium to accomplish changes in the adjustment patterns of human beings is not likely to succeed, at least by itself. This book does communicate some very important ideas in a readable form. It is therefore better than most such books, and could well be used as an adjunct in counselling some sorts of people.

ALFRED L. BALDWIN

THE EMOTIONS: OUTLINE OF A THEORY.

By Jean-Paul Sartre. Translated from the French by Bernard Frechtman. Philosophical Library, New York. $2.75. vi + 97 pp. 1948.

In this little book, Jean-Paul Sartre has attempted to sketch a phenomenological theory of the emotions. Beginning with the James-Lange theory, which he quickly discards, he shows that emotions have a signification. The crux of his theory is that emotions, in their infinite variety, have in common that they proceed as a total organismic function that grasps the external world by a degradation of the conscious processes, and an investment in the external world by means of the laws of magic with the experienced emotions attaching themselves to the external world by a process of projection.

The physiological phenomena represent the "seriousness" of the emotion. Sartre states: "We can then grasp the essential point: emotion is a phenomenon of belief. Consciousness does not limit itself to projecting affective signification upon the world around it. It lives the new world which it has just established. Thus the origin of the emotion is a spontaneous and lived degradation of consciousness in the fact of the world." He adds two provisos to this, however. "First, that consciousness does not theoretically have consciousness of itself as degrading itself in order to escape the pressure of the world; it has only positional consciousness of the degradation of the world which takes place on the magical level. Second, that consciousness . . . precisely because it lives the new aspect of the world by believing in it . . . is caught in its own belief, exactly as in dreaming and in hysteria."

In speaking of the magical world, he refers to the world "as a non-instrumental totality, that is, modifiable by large masses and without an intermediary." ". . . there is emotion when the world of instruments abruptly vanishes and the magical attitude, one of the great attitudes which are essential to it, with appearance of the correlative world, the magical world. Emotion is not an accident. It is a mode of existence of consciousness, one of the ways in which it understands (in the Heideggerian sense of 'Verstehen') its 'being-in-the-world'."

This little book of only 94 pages plus an index is exceedingly difficult going, and when one gets to the end of it, one wonders if it is worth it. I rather fancy not, except for philosophers who need this exercise in logic to bring the commonplace facts of emotions into their philosophical systems. How can this book possibly serve as the starting point for a series of monographs, each to deal with an individual emotion—joy, sadness, and so on—as the author hopes? It all sounds rather arid.

WENDELL MUNCIE

THE NORMAL SEX INTERESTS OF CHILDREN. *From Infancy to Childhood.*

By Frances Bruce Strain. Appleton-Century-Crofts, New York. $2.75. x + 210 pp. + 1 plate. 1948.

This is a pleasantly written book on the normal sexual development of children. It is based on sound psychiatric concepts of the different developmental stages, and Mrs. Strain makes no effort to gloss over the facts or talk down to her audience. She assumes a certain amount of intelligence and sensitivity in the reader and objectively states her point.

Before preparing her theoretical material, she gives illustrations of sexual interest and how they are displayed in children from infancy through adolescence, her object apparently being to establish that there is a sexual drive manifest from the very earliest time. Using these illustrations as a background, she then describes the anal, the oral, and the genital erotic experiences and their early expressions. She suggests ways to deal with these in such a manner as not to warp the youngster. Her point of view is an understanding one. I feel that this is an excellent book to

recommend to anyone concerned with the care and training of children.

HELEN ARTHUR

MENTAL HYGIENE. *The Dynamics of Adjustment.*

By Herbert A. Carroll. Prentice-Hall, New York. $5.00. vi + 329 pp. 1947.

This elementary textbook for courses in mental hygiene presents a short survey of the problems of personality development. Because it is for beginning students, concepts of motivation and various needs receive considerable attention. Following this general discussion, learning and adjustment are considered, and then the neuroses and psychoses receive a chapter each. Finally, there are chapters on school problems and mental deficiency, testing, and therapy.

One interesting emphasis in the book is that placed upon the social importance of the several problems. At various places throughout the discussion there are tables of incidence and other discussions of the magnitude of the problem of mental hygiene. There is also a wealth of case material from the author's own experience, along with other published cases from the literature.

In spite of the adequacy with which the subject is covered, there is some doubt whether the book will appeal to elementary classes in mental hygiene. It reads too like a series of sections, each excellently organized and paragraphed, but the whole not very coherently unified into an effective presentation of this very important subject.

ALFRED L. BALDWIN

THE MENTALLY ILL IN AMERICA. *A History of Their Care and Treatment From Colonial Times. Second Edition.*

By Albert Deutsch. Columbia University Press, New York. $5.50. xxiv + 555 pp. + 8 plates. 1949.

There is a group of scientific and medical journalists who, through their accurate and scholarly reporting of scientific subjects for the lay public, have gained the confidence of academic people. Albert Deutsch is one of the better known members of this group, and this treatise on the development of the care and treatment of the mentally ill constitutes an excellent contribution to historical medical literature. Undoubtedly some readers may object to certain parts because of the dramatic emphasis. Such treatment of data is to be expected of Deutsch, as he is by training and inclination a newspaper man. However, he is also a capable social historian, and this work shows that he has put a great amount of research into its preparation. It is also apparent that the hundreds of references were selected with scrupulous care.

In general, this book traces the origin, from early Colonial times, of the public attitudes and prejudices toward mental illness. Deutsch dramatically relates the terrific effort made at various times to overcome medical, as well as public, ignorance and misconceptions concerning the mentally sick. Books such as this should be more widely read; they would do much to bring about a better understanding of such problems by the citizens.

DAVID B. TYLER

MENTAL HEALTH IN MODERN SOCIETY.

By Thomas A. C. Rennie and Luther E. Woodward. The Commonwealth Fund, New York; Geoffrey Cumberlege, Oxford University Press, London. $4.00. xviii + 424 pp. 1948.

As a source of information about mental hygiene facilities, methods, the results of treatment in the armed services, veterans' services, industry, schools, pastorates, etc., this book is to be recommended. It gives excellent advice on actual methods in counselling practices.

WENDELL MUNCIE

FUNDAMENTALS OF PSYCHOANALYSIS.

By Franz Alexander. W. W. Norton & Company, New York. $3.75. 312 pp. 1948.

This is one of two volumes into which the author is expanding his work on *The Medical Value of Psychoanalysis.* The present book deals strictly with the fundamental tenets of psychoanalysis. The chapter headings indicate the scope of the book: The Position of Psychoanalysis in Medicine; The Nature of Psychological Understanding; The Basic Principles of Psychodynamics; The Concept of Sexuality; Function of the Ego and its Failures; Sociological Considerations; The Psychology of Dreaming; Unconscious Factors in Wit and Aesthetic Appeal; Psychopathology; The Principles of Psychoanalytic Therapy. In the chapter on the basic principles of psychodynamics, Franz Alexander stresses three principles: of stability, of economy or inertia, and of surplus energy, the last named being basic for growth and propagation.

In this book, the author has written a classic statement of the principles underlying psychoanalysis. The writing is clearcut and stripped of the long, historical accounts which are wholly unnecessary to the intelligent reader of the present day. When touching on controversial problems, the author manages to state the pros and cons, and to leave the problems where they actually stand today. The chapters concerning the Function of the Ego and Its Failures, and psychological consideration are especially interesting. The chapter on The Psychology of Dreaming gives the best state-

ment I have seen regarding the functions of dreams and the practical aspects of their interpretation. In particular, the explanation of dreams with an unpleasant content appears to be the most understandable statement explaining the derivation of this sort of dream from the wish-fulfilling function that has been presented anywhere. This is a book to be read and reread.

WENDELL MUNCIE

TAKE OFF YOUR MASK.

By Ludwig Eidelberg. International Universities Press, New York. $3.25. 231 pp. 1948.

This is another one of several volumes that have appeared recently, designed to give in condensed form an insight into what happens in a therapeutic session. Actually, the author has condensed experiences from many patients and many psychoanalytic sessions into a single telling session. In the Preface, he makes this nature of his content clear, so that the careful reader will not take it at face value for the results from a single session, as it is presented. He does very well in showing the psychotherapists' actual work in meeting the problems, resistances, and evasions of patients, and the lay reader and even the trained reader will profit by the material here presented. There are eight chapters, each of which deals with a different kind of problem.

WENDELL MUNCIE

MODERN TRENDS IN PSYCHOLOGICAL MEDICINE.

Edited by Noel G. Harris. Paul B. Hoeber, Medical Book Department of Harper & Brothers, New York and London. $10.00. xii + 450 pp.; ill. 1948.

This is an excellent compendium of modern trends in psychiatry, with excellent contributions ranging from electrophysiology to psychotherapy and world affairs. The authors are well chosen and give authoritative accounts of their several topics. As a review of the best current trends, it is to be recommended heartily.

WENDELL MUNCIE

READINGS IN THE CLINICAL METHOD IN PSYCHOLOGY.

Edited by Robert I. Watson. Harper & Brothers, New York. $4.50. xii + 740 pp. 1949.

This book, under the general editorship of Gardner Murphy, is a compendium of contributions on clinical psychology from acknowledged leaders in every field. The book is in four parts: Clinical Method; Functions of the Clinical Psychology; Diagnostic Methods; and Methods of Treatment. 272 pages out of a total of 733 are devoted to methods of treatment, a quite remarkable proportion. I cannot think of any psychiatric textbook which has a comparable amount of space devoted to the methods of treatment. Does this mean that the psychologists know more about treatment than the psychiatrists themselves? It hardly seems to. Rather, it appears to mean that the psychologists are very alert to their growing opportunity in this direction. Again, a great deal of space has been taken up by the transcript of a phonographic recording of an example of a "short-term non-directive treatment of an adult," together with a "critique of non-directive methods of psychotherapy" and a rebuttal of the critique. All of this makes interesting reading, in particular because the detailed case of non-directive treatment recorded here follows in certain respects the training system which used to be part of the Phipps Clinic program under Adolf Meyer. The footnotes to this recorded case take the place of those marginal notations which we of the Phipps Clinic were asked to make concerning our interpretation of the material in the body of the report. The present treatment is, however, better systematized than our old methods were, a fact lending strength to the assertion made in the text that Dr. Carroll R. Rogers has actually contributed something essentially new to psychotherapy. Robert I. Watson, the editor, has given a particularly lucid review of the treatment methods of various schools and splinter movements from them, including even such recent developments as psychodrama and psychotherapy.

For a short statement of the motives and methods of the various schools of clinical psychology and psychiatry, one could hardly find a more clearcut, concise statement. In general, this is a valuable book for psychiatrists as well as for clinical psychologists, whose fields truly overlap.

WENDELL MUNCIE

CURRENT TRENDS IN CLINICAL PSYCHOLOGY. *Annals of The New York Academy of Sciences. Volume XLIX, Article 6.*

By A. W. Combs, H. E. Durkin, M. L. Hutt, J. G. Miller, J. L. Moreno, and F. C. Thorne. The New York Academy of Sciences, New York. $1.50 (paper). Pp. 867–928. 1948.

This volume expresses the uncertain status of clinical psychology, the need for the clarification of its objectives, training procedures, and relationship to psychiatry. As a statement of its manifold potentialities, it is excellent and will repay close perusal.

WENDELL MUNCIE

ABNORMAL PSYCHOLOGY. *A Clinical Approach to Psychological Deviants. McGraw-Hill Publications in Psychology.*

By James D. Page. McGraw-Hill Book Company, New York and London. $4.00. xviii + 441 pp.; ill. 1947.

This volume is a textbook for a course in abnormal psychology. It is fairly traditional in its treatment of the material, beginning with a discussion of the general relation of normal to abnormal behavior, and then proceeding through a theoretical section to the discussion of the psychoneuroses and their treatment. Following this section psychoanalysis and its variants are discussed. A discussion of the psychoses follows, and the book ends with chapters about various disorders not easily classified in the previous scheme, e.g., delinquency, mental deficiency, and organic psychoses.

The handling of the material within each of these sections is rather pedestrian also. There are well organized descriptions of various disorders, with considerable case material, but the emphasis seems to be upon clear statement of factual material rather than upon understanding the behavior of neurotics and psychotics. There is a glossary, a list of available visual aids, and a good index.

ALFRED L. BALDWIN

THE BASIC NEUROSIS. *Oral Regression and Psychic Masochism.*

By Edmund Bergler. Grune & Stratton, New York. $5.00. xiv + 353 pp. 1949.

Here is an exceedingly interesting book, in which Bergler has put together the content of a number of papers published over the years on a topic about which there must exist a great deal of controversy, especially over the theory of the dynamics concerned, although scarcely at all regarding its clinical significance. Bergler has gradually come to conclude that there exists but one neurosis. This he describes in terms of oral regression and psychic masochism, and holds the various classical neurotic syndromes to be simply "many rescue stations in later development erected intrapsychically for the purpose of escaping the deepest of all mortal dangers—psychic masochism." According to Bergler:

"Oral neurotics are people who constantly provoke the situation of the following triad of the 'mechanism of orality:'

"(1) I shall repeat the masochistic wish of being deprived by my mother, by creating or misusing situations in which some substitute of my pre-oedipal mother-image shall refuse my wishes.

"(2) I shall not be conscious of my wish to be refused and initial provocation of refusal, and shall see only that I am justified in self-defense, righteous indignation and pseudo-aggression because of the refusal.

"(3) Afterwards I shall pity myself because such an injustice 'can happen only to me,' and enjoy once more psychic masochistic pleasure.

This triad induces the ego-strengthening mirage of aggression, while in unconscious reality the wish to be refused, deprived and mistreated is foremost. Under the disguise of pseudo-aggression the oral neurotic enjoys masochistic self-pity and the pleasure of being refused."

According to the author, every child labors under "the septet of baby fears and lives through the following dreads: fear of being starved, devoured, poisoned, choked, shot to pieces, drained, castrated." He concludes that every case in which the mechanism of orality is discernable in decisive situations in life—in work, love, or personality—is a justification for classifying that neurotic person as orally regressed, quite apart from whatever other symptoms and signs he may show. Bergler states that every patient enters analysis with five aims: one of them conscious, and four unconscious. The conscious wish of the patient is that he is suffering and wants help. His unconscious aims are as follows: 1) materialization of the unconscious wishes in the transference-neurosis; 2) a wish not for a cure but for stabilization of his neurotic balance, or in other words, a continuation of the neurosis but with a lessening or elimination of inner guilt; 3) a desire to strengthen his inner defense mechanisms in order to maintain the aim described just above; and 4) when he finds out that aims (2) and (3) are not to be achieved, he aims at the maintenance of the neurosis with whatever compromises he has to make. That is to say, he makes the best bargain he can.

Bergler has this to say about the prerequisites for successful treatment: "There is one more prerequisite necessary besides neurotic illness, money, and knowledge of analysis, to make a workable patient. This indispensable prerequisite is an, at least potentially fluctuating, inner feeling of guilt. I do not mean feeling of guilt *per se*, since every neurotic is full of it. The problem is the deposition of that guilt. As long as the balance of guilt and absorption of it in neurotic unhappiness is fair, the neurotic will not enter analysis —despite his suffering."

In the author's opinion, every neurosis rests on the following basis: "1) The conflict of unconscious and repetitive. 2) The end-result of the infantile conflict in neurosis is always oral-masochistic. 3) Every neurosis represents a rescue-attempt from the oral danger. 4) Every neurotic symptom has a three-layer structure: only the defense against the repressed wish becomes visible. 5) Every neurotic aggression is but pseudo-aggression. 6) The differentiation between 'leading' and 'misleading' unconscious identification gives the clue to the resultant neurotic personality. 7) In every neurosis fear is predominant. 8) Every neurosis is regulated by the mechanism of acceptance of inner guilt for the 'lesser crime.' 9) Neurosis is a progressive and not self-limiting disease."

A large part of the book is devoted to clinical descriptions of examples of oral regression that illustrate a

variety of symptom pictures, for example, the oral character-neurosis, premature ejaculation, psychogenic oral aspermia, oral type of rigidity, specific type of promiscuity, pathologic blushing, writer's block, pseudo-mental deficiency, writer's cramp, retirement neurosis, homosexuality, kleptomania, overeating and gourmanderie, logorrhea, and so on. There follow chapters on differential diagnosis and prognosis, and some predictions about future therapy. Bergler feels that such cases cannot be treated under one and a half to two and a half years, with at least three appointments a week. He expresses some optimism regarding the outcome of treatment by prevention through education, but he points out that education is very likely to leave the pupil able to see the trouble in others but not in himself.

At various points throughout the presentation of this material, the author takes on an argumentative tone and castigates the opponents of his theories. As one who is not a psychoanalyst, the reviewer can look on from the side lines at these intra-family quarrels with a certain detachment, without having his interest in the clinical descriptions and the potential benefits of treatment being in the last minimized by this melee. A great deal of the worth-while observation and even speculation in this book may be useful in the treatment of our most difficult neurotic cases. Whether the basic theories are correct or not is anyone's guess. Bergler himself points out that substantiating material of a factual nature, coming from the patients themselves, is pretty hard to secure, but all psychiatrists have had the experience of seeing patients who are willing to accept unprovable theories, if these seem to be to their own advantage.

WENDELL MUNCIE

WHICH WAY OUT. *Stories Based on the Experience of a Psychiatrist.*

By C. P. Oberndorf. International Universities Press, New York. $3.25. ii + 236 pp. 1948.

This is a book dealing with common psychiatric problems treated by the psychoanalytic method. A great deal of material collected from many patients has been condensed into a readable story that centers around the experiences of a fictional practicing psychoanalyst. The book is thus intended to give a lay reader an idea of psychoanalytic therapy and does not pretend to be an account of what actually transpires in any one of several hours of psychoanalytic work. The author has applied his beautiful expository style to this project, and the book is consequently wholly readable and informative. To a psychiatrist, the introductory chapter, which explains the author's aims and gives some of his comments on the genesis of psychiatric problems, is most enlightening and welcome. Here indeed he exhibits that breadth of vision for which he is so well known in his field.

WENDELL MUNCIE

A STUDY OF INTERPERSONAL RELATIONS. *New Contributions to Psychiatry.*

Edited and with an introduction by Patrick Mullahy. Hermitage Press, New York. $6.50. xxxii + 507 pp. 1949.

This is a volume of contributions culled from the literature by psychoanalysts and psychoanalytically oriented psychiatrists, anthropologists, and sociologists from the Washington School of Psychiatry. There is an introduction by the editor, who points out the divergence of the Washington School of Psychiatry from some of the traditional Freudian doctrines, and its claims to an eclectic viewpoint, which is considered desirable. A variety of papers deals with such topics as Memory and Childhood Amnesia (Schachtel); Transference (Janet Rioch); the Philosophy of Mental Disorder (Fromm-Reichmann); Cultural Pressures in the Psychology of Women and the Role of Women in this Culture (Clara Thompson); Person, Personality, Group, Culture (Lasswell); the Management of Paranoid Trends (Sarah Tower); the Management of Anxiety in a Case of Paranoid Schizophrenia (Robert Cohen); the Period of Frustration in Creative Endeavor (Eliot D. Hutchinson). This is a welcome compilation of interesting contributions to the study of interpersonal relations and their management from an active and, on the whole, rather wise School.

WENDELL MUNCIE

HUMAN BIOLOGY

HUMAN GEOGRAPHY. *An Ecological Study of Society. By C. Langdon White and George T. Renner. Appleton-Century-Crofts, New York and London.* $6.00. xii + 692 pp.; ill. 1948.

This is a new textbook by the authors of a previous text called *Geography as Human Ecology.* The theme of the former book was that of the physical environment dominating man. This book is considerably improved in outlook as well as greatly expanded in content.

Faced with the dilemma of where to begin in such an all-inclusive subject as human geography, the authors have decided to include everything. Hence there is a large physical geographic section: weather and climate and the principal climatic regions; natural vegetation; native animal life; microscopic life forms; physiography; soils; minerals; hydrography. There follows: Problems of Space, essentially a section on anthropology and sociology. Finally there comes a section on geograph-

ical theory. The authors have used the theme of the relationship of man to his environment as a unifying element.

The authors' point of view is that geography is primarily *human ecology:* the study of human society in relation to the earth background. "The key concepts of geography as human ecology are those of geographic adjustment and relationship" (p. 632). Although it is granted that "the kind of work men do depends in some measure upon their desires, ideas, and skills—in larger measure it depends upon what resources are present in their natural environment." This suspiciously environmentalist statement is further strengthened by allusions to the influence of the physical environment on art and music, repressive environments, the alleged depressing effects of tropical climates, and so forth. Further, the authors follow Griffith Taylor for their origins and hierarchy of races and outdo Ellsworth Huntington in ascribing merits to selection through migration. Thus, California's rise is due to: 1) Nordics who migrated into Europe, of whom the Angles and Saxons who reached the North Sea coast were probably the most rigorously selected; 2) those who settled eastern England, who were probably the most able and enterprising, the cream of these becoming religious nonconformists; 3) the most intelligent and independent of these, who migrated thence to New England, and the most energetic of whom migrated further westward; 4) the most resourceful and persistent among these, who reached California. This is a better book than its predecessor, but still in need of improvement.

GEORGE F. CARTER

THE EARTH AND MAN. *A Human Geography. Revised Edition.*

By Darrell Haug Davis. The Macmillan Company, New York. $5.50. xxiv + 696 pp.; ill. 1948.

This book was planned as a textbook to meet the needs of beginning geography classes in American colleges and universities. It is a treatment of man and his economic activities in their areal environmental settings. The book is divided into the following main parts: A Study of Terrestrial Unities; Introduction; Man: His Distribution and Numbers; Man and Environment; The Elements of the Physical or Natural Environment; How Man Obtains His Livelihood; and an Appendix. The author states in his Preface that he has had two objectives in view: first, to supply a background of factual material and principles of value to all students; and second, to establish certain facts and principles concerning regional possibilities, as these are affected by environmental conditions both singly and in selected combinations, and so to lay a foundation upon which those planning additional work in the subject may build. The complete synthesis of these factors is presumed to be dealt with in regional courses. This new edition reveals considerable internal evidence that there has been considerable revision. On the other hand, there is no mention or recognition of certain radical changes which developed in the course of, and as a consequence of, World War II. This defect results in a certain lack of reality of conditions described in the book, considering those we know to exist at the present time. In spite of the large amount of space taken up by the 402 figures, most of them quite appropriate, large, and with long legends, there is an enormous amount of textual material, amounting to 590 double column pages. The illustrations are appropriate and excellent, on the whole, but the legends, which run clear across the page, are somewhat difficult to read because of the length of the lines. As to make-up, the sideheads could well be in black face, and the paragraph headings are hardly prominent enough. It is evident from both the illustrations and text that the author is familiar with Japan. This adds much to his presentation of conditions in that part of the Orient. It is to be regretted that the author has not had a similar first-hand acquaintance with the tropics. His interpretation of conditions in the low humid latitudes is rather too conventional, almost stuffy, although in general his language is clear, straightforward, and fresh, with an absence of clichés or conventional statements. In some places one would rather like a somewhat different emphasis. For example, too much space seems to be devoted to how petroleum came to be formed, and when the author discusses navigation there seems to be no reference to the fact that pilotage is usually compulsory in most harbors of the world at the present time. Also relating to the sea is the implication that everywhere there are two high tides and two low tides per day, whereas actually along considerable portions of the coasts of the world there is only one high tide and one low tide per day, at least for much of the year. It might also have been mentioned that at the present time magnesium metal is produced in large quantities from sea water. In a number of instances the author incorrectly refers to soils high in soluble salts as being alkaline. Although it is true that sometimes saline soils are alkaline, usually salts in excess make the soil neutral.

Davis repeatedly refers to the destruction of forests for the production of food or other subsistence crops, and usually states or implies a criticism of this. However, kaingining is a logical method of producing subsistence crops, particularly on poor soils, in humid tropical regions. The forest actually serves as a long-time cover crop, restoring plant nutrients and soil structure as well as eliminating weeds. When these have been accomplished, the forest is cut, burned, and the shallow-rooted annual subsistence crops, for food or fiber, are planted. It is true that a large

amount of labor is used in this way, but the natives in those regions have abundant labor but lack the means to obtain fertilizers to restore plant nutrients to the soil, and without the addition of plant nutrients most soils in humid tropical lowlands cannot as a rule produce annual crops for more than two or three years. One can only wish that the author would spend some time in the humid low latitudes before he writes the next edition of his book. Field work in the tropics for a year would add greatly to his presentation of the subject from the standpoint of the world as a whole, particularly in view of the misconceptions that prevail at the present time regarding the humid, low latitudes. The author considers the plantation method of agriculture in tropical regions at some length, yet seems unaware of the fact that in certain tropical regions native production of formerly exclusive plantation crops is increasing. For example, before Pearl Harbor the natives in the Netherlands East Indies were producing 70 per cent of the total rubber output of that leading *Hevea* rubber-producing region of the world. Though capital is necessary for processing certain products such as tea, coffee, and sugar for overseas markets, large investments of capital are not necessary for preparing rubber for sale and export to the Occident.

ROBERT L. PENDLETON

AN ANTHROPOLOGICAL BIBLIOGRAPHY OF THE EASTERN SEABOARD. *Eastern States Archeological Federation, Research Publication Number 1.*

Compiled and edited by Irving Rouse and John M. Goggin. Eastern States Archeological Federation at the Yale Peabody Museum, New Haven. $2.50 (paper). 174 pp.; ill. 1947.

The passage of years adds to the mass of literature in all subjects, and bibliographies become increasingly welcome additions as the problem of finding one's way becomes ever more arduous. This is a particularly well planned bibliography. The material is arranged under the subject headings of archeology, ethnology, and history; and for each subject, under the areal headings of Eastern Canada, New England, Middle Atlantic States, and the Southeast. Each of the area headings has 6 to 8 subdivisions. In addition to this most useful system of cross-filing, there is an Introduction that states purposes and methods, and there are keys to abbreviations and keys to classification. The latter supply a correlation of States with Tribal Groups, as well as a Tribal Classification and Synonymy. This is, then, a most useful tool for anyone who touches upon any part of the problem of Indian occupance of the Eastern Seaboard.

GEORGE F. CARTER

THE AYMARA INDIANS OF THE LAKE TITICACA PLATEAU, BOLIVIA. *American Anthropologist, Volume 50, Number 1, Part 2. Number 68 of the Titles in the Memoir Series of the American Anthropological Association.*

By Weston La Barre. American Anthropological Association [Bloomington, Indiana]. $3.50 (paper). 250 pp. + 13 plates. 1948.

The tendency toward encyclopedic studies in anthropology is strong. Herewith, another one. La Barre spent seven months in the field and, one gathers, a great many more months in the library. The data thus gained has been organized under the following headings: The Country and the People; Food, Clothing, Shelter and the Material Arts; Social, Economic, and Political Organization; Magic and Religion; Native Knowledge, or Folk Sciences; and Medicine. There are eighty subtopics under these main headings. Biologists will find material of interest scattered throughout.

Physical Anthropology, Food and its Preparation, Birth, Childhood, Courtship, Marriage, Death, Cannibalism, Suicide, Dreams, Magic, Ethnoanatomy and Ethnophysiology, Ethnoanthropology, Ethnopsychology, Diseases and Pathology—here are titles of subsections that show the range of material which might interest readers of this journal. However, most of the sections will be found rather thin from the specialist's viewpoint. The work is, however, a good source of raw material for the specialist in any such topic as, for example, primitive medicine.

GEORGE F. CARTER

THE POPULATION OF MICHIGAN 1840 TO 1960: AN ANALYSIS OF GROWTH, DISTRIBUTION AND COMPOSITION. *Michigan Governmental Studies, Number 19.*

By Amos H. Hawley. University of Michigan Press, Ann Arbor. $1.50 (paper). viii + 116 pp.; ill. 1949.

This is a neat if somewhat pedestrian exercise in formal demography, with little background analysis or interpretation. Based on census data, it covers total population, natural increase, migration, regions within the state, urbanization and related subjects, and the distribution of population by sex, age, color, and nativity. The analysis of past trends is carried up to 1945, but the more recent studies of the Census Bureau have not been considered. A projection of the population by age and sex to 1960 is also included. The volume should be valuable primarily for scholars within the state, but it may also serve as a handy reference book for others interested in regional trends.

CHRISTOPHER TIETZE

A STUDY OF THE GLACIAL KAME CULTURE IN MICHIGAN, OHIO, AND INDIANA. *Occasional Contributions*

from the Museum of Anthropology of the University of Michigan. Number 12.

By Wilbur M. Cunningham; with an appendix by James B. Griffin. University of Michigan Press, Ann Arbor. $1.50 (paper). viii + 51 pp. + 11 plates. 1948.

In the areas named in the title certain burials have been found quite deep in the gravels of the Glacial Kames. They have a few features in common, the most important being an artifact shaped like a shoe-last. Most of the material reported was obtained by farmers, construction workers, and others who had occasion to dig into these gravel deposits. The data have been collected primarily from the literature. As the author points out, they suffer from the nature of their acquisition. Griffin points out in the Appendix that there is relatively little in common to the different sites described; and that they do not give a cultural picture, but only a burial complex, and not, certainly, a single burial complex at that. Cunningham has nonetheless done a useful job in gathering up such data as exist, and in calling attention to the problem. Archeologists in that area should now watch for similar finds—gravel deposits are surely still being worked—and add critical data that will serve to solve this riddle.

GEORGE F. CARTER

SOCIAL PROBLEMS ON THE HOME FRONT. *A Study of War-Time Influences.*

By Francis E. Merrill. Harper & Brothers, New York and London. $3.50. xii + 258 pp. 1948.

Here is an excellent survey of the consequences of the war upon the several varieties of social disorganization. Specifically, the effects of the war upon the following kinds of disorganization are discussed in one chapter each: family disorganization, childhood, adolescence, sex offenses, prostitution, delinquency, crime, and personal disorganization.

In the discussion of each topic the author attempts to summarize the general findings about the factors that underlie that particular type of disorganization. Then the characteristic effect of the war upon those factors is discussed with whatever evidence is available. Along with this are summaries of the actual data about the frequency of divorce, sex offenses, etc.

The book is particularly interesting for its compilation of so many data relevant to the various problems of social and personal disorganization. In a good many cases these data are reasonable consequents of what is known about the factors, but frequently, of course, the state of knowledge is not sufficient to account for the findings. The author maintains a consistently detached viewpoint in her discussion of the problems. Her moral, political, and theoretical viewpoints are not permitted to influence the discussion of the data. One consequence of such an attitude is, of course, that the book contents itself with being a descriptive discussion rather than a critical analysis of the way the social problems of the war were handled.

ALFRED L. BALDWIN

ELMTOWN'S YOUTH: *The Impact of Social Classes on Adolescents.*

By August B. Hollingshead. John Wiley & Sons, New York; Chapman & Hall, London. $5.00. xii + 480 pp. 1949.

ADOLESCENT CHARACTER AND PERSONALITY.

By Robert J. Havighurst and Hilda Taba. John Wiley & Sons, New York; Chapman & Hall, London. $4.00. x + 315 pp.; ill. 1949.

These two books are described by the publisher as "companion volumes." They do indeed have several fundamental factors in common. Each is a study of adolescence in a community. In each of these studies the authors, all of them well-trained, scholarly observers, actually went to particular middle-western towns where they could carry on an investigation of real personalities within the particular group. Both books are handsome examples of how a complicated and far-reaching project in psycho-sociological research is planned, conducted, and written up. However, in spite of these similarities, each book has an entirely different flavor and contributes to quite different aspects of the adolescent and his problems.

In *Elmtown's Youth*, Hollingshead has reported on the observations made while he and his family themselves lived as members of "Elmtown." He studied the social system of the community as a whole and specifically made an analysis of the lives of 735 adolescents. He and his wife did a tremendous job of interviewing, getting acquainted with, and overcoming the suspiciousness of a small town in order to assemble the convincing data around which this book is built.

Hollingshead found that his community was stratified into five classes. Class 1 is the aristocracy, the land-owning, politically and economically powerful group. Class 2 comprises the people in good positions, slightly below the exclusive Class 1 but nevertheless economically sound and with a sense of prestige which goes with big jobs. Class 3 is a group in which families are not so well educated, do not live in the best residential section, and have a moderate but stable income. Class 4 are the poor but honest, hard-working families who never seem to get beyond a certain low economic status. Class 5 is the riffraff. Each group is given a certain location in the city and in the minds of the Elmtown citizens, and those adolescents who try to step across these class lines are severely criticized by the community and are not accepted by their peers. The consideration and special treatment accorded to the adolescents of Class 1, and the discrimination and

snubbing meted out to the Class 5 adolescents is uniform throughout the community.

Despite the scientific approach and organization of this study, *Elmtown's Youth* has a compelling quality which makes it fascinating reading. The impact comes not only from the author's style, which is vivid and very human, but arises also from his descriptive analysis of these classes. There is something rather horrifying about the stark, unemotional presentation of class consciousness as it operates on actual youngsters in an actual community. The book certainly documents the reasons why educated parents go to almost any lengths to get their adolescents out of a small town, where their life lines will inexorably be defined by group pressure and family status and not by their individual worth or potentiality.

Adolescent Character and Personality, while it is a worth-while book, and carefully done, is just not as interesting reading as *Elmtown's Youth*. This is probably due in part to the fact that the writing in the second book is by several people instead of by a single author. Also, the subject matter doesn't pack quite the wallop that an exposé of class tyranny does.

Havighurst and Taba, assisted by a number of coworkers, made a study of all the youths in "Prairie City" who were sixteen years old in 1942. A number of factors were evaluated for their effect on the individual's character formation; viz., the influence of social class, school adjustment, the church, adults outside the subject's family, moral beliefs of the community, and the personal social adjustment of the individual. After a thorough analysis, the authors felt that five character types could be defined among the adolescents: the self-directed person, the adaptive person, the submissive person, the defiant person, and the unadjusted person. The self-directed young person is the one who has made the most sound character development.

In conclusion, Havighurst and Taba make a number of suggestions about what "Prairie City" could do to help more adolescents become self-directed people. These are practical suggestions but meet the difficulty that in order to effect them, "Prairie City" will have to develop a new perspective on its responsibilities to its youth. It will have to revamp its educational system and appropriate more money and space for its high school program. *Elmtown's Youth* indicates that the prospect of such changes coming about in the near future is very unlikely.

HELEN ARTHUR

BIOMETRY

QUANTITATIVE METHODS IN PSYCHOLOGY. *By Don Lewis. The Bookshop, Iowa City, Iowa.* $4.25 (paper). viii + 286 pp. 1948.

It is a common observation that most graduate students have a great deal of difficulty in understanding many quantitative articles they are required to read. Those students who have had at least a course or two in calculus seem to do better than the others, but the difficulty cannot always be traced to inadequate training in mathematics. The main trouble appears to be that most courses in mathematics are taught for mathematicians and engineers. As a result, students in the biological sciences never seem to learn the kinds of mathematics they need to know. Even when they do learn the right sorts of mathematics, the techniques are seldom related to problems which are most meaningful to the student.

This book is essentially a treatise of those mathematical techniques the graduate student in psychology should know. The titles of the ten chapters are: Variables, Constants, and Functional Relationships; Fitting Curves to Empirical Data: I. Linear Functions; Logarithms; Fitting Curves to Empirical Data: II. Complex Functions; Differentiation; Integration; The Normal Curve; Distribution Functions; Applications of Equations; and Goodness of Fit.

The presentation is clear and, although the student need have only algebra as a prerequisite, he should be reasonably conversant with some high-powered mathematics when he reaches the end of the book. Especially noteworthy is the liberal sprinkling throughout the text of problems and examples drawn from the scientific literature. Incidentally, the problems all come from experimental and physiological psychology, so that the student of quantitative biology should not find them difficult to understand. This is a book which every graduate student in experimental psychology should read.

A. CHAPANIS

DE OMNIBUS REBUS ET QUIBUSDAM ALIIS

SCIENCE IN PROGRESS. *Sixth Series. Sigma Xi National Lectureships 1947 and 1948 and the Silliman Lectures, 1947, Presented at the Centennial of the Sheffield Scientific School, Yale University, October 1947. By H. D. Smyth, John A. Wheeler, Ernest O. Lawrence, Glenn T. Seaborg, Linus Pauling, L. Zechmeister, W. M. Stanley, René J. Dubos, G. W. Beadle, A. H. Sturtevant, and Charles E. Kellogg; edited by George A. Baitsell. Yale University Press, New Haven.* $5.00. xvi + 322 pp. + 1 map; text ill. 1949.

This latest volume of *Science in Progress* brings together, as is customary, selected papers that have appeared in whole or in part in the *American Scientist*. Of the eleven papers in the present volume, seven are based upon manuscripts prepared originally for presentation in the Sigma Xi National Lectureships during

1947 and 1948. The remaining four papers, Chapters III, V, VII, and IX, are based upon Silliman Lectures presented at Yale University in October, 1947, on the occasion of the Centennial of the Sheffield Scientific School. The contributions are as follows: From X Rays to Nuclear Fission, by H. D. Smyth; Elementary Particle Physics, by John A. Wheeler; High Energy Physics, by Ernest O. Lawrence; The Eight New Synthetic Elements, by Glenn T. Seaborg; Chemical Achievement and Hope for the Future, by Linus Pauling; Chromatography and Spectroscopy in Organic Chemistry and Stereochemistry, by L. Zechmeister; Virus Research: Achievement and Promise, by W. M. Stanley; The Tubercle Bacillus and Tuberculosis, by René J. Dubos; Genes and Biological Enigmas, by G. W. Beadle; The Evolution and Function of Genes, by A. H. Sturtevant; Modern Soil Science, by Charles E. Kellogg.

Here is a volume which truly presents science in progress. It should command a wide variety of readers, from serious-minded laymen to science teachers in secondary schools and to professional scientists. It is an incomparable source of up-to-date information presented by specialists and written in a style that will hold the interest of a wide group of readers possessing varied levels of scientific background.

V. G. DETHIER

SCIENCE NEWS—9.

Edited by J. L. Crammer. Penguin Books, Harmondsworth, Middlesex. 1s. 6d. (paper). 160 pp. + 16 plates; text ill. 1948.

This number contains, among 12 articles, the following on biological topics: Aspects of Bee Behaviour (Colin G. Butler); Telepathy (Eric J. Dingwall & Denys Parsons); Research Report, including the structure of vaccinia virus before and after digestion with pepsin, the discovery of exo-erythrocyte stages in the life cycle of the malaria parasite, and the use of D.D.T. in controlling malarial mosquitoes (A. W. Haslett); Taste and Flavour (R. W. Moncrieff); Farming Front, including a report on American foul brood, a disease of bees (R. N. Higinbotham); Exploring Jan Mayen, including reports on non-breeding among Arctic birds and on the limits of endurance of climatic conditions by plants (A. J. Marshall; J. W. Wilson). The present issue maintains fully those high standards of interest and accuracy set by earlier numbers of *Science News*. Busy teachers will find many items they can use in each issue.

THE STORY OF LINEN.

By William F. Leggett. Chemical Publishing Company, Brooklyn. $2.75. xii + 103 pp. 1945.

THE STORY OF WOOL.

By William F. Leggett, with a foreword by Sylvan I. Stroock. Chemical Publishing Company, Brooklyn, New York. $5.00. vi + 304 pp. 1947.

The author of these two books has collected quite a variety of information, biological, geographical, and historical, about linen and wool, two of the three fibers most anciently and widely used by mankind. Although one might note a degree of repetitiousness in reading either book alone, the author's ingenuity in the endeavor to write two books for the labor of one is not fully apparent until the two books are collated. A few samples will convey the full flavor of the author's scholarship:

A. From *The Story of Linen:* "The dress of the early Romans is thought to have had its origin in the Etruscan dress of 800 to 400 B.C. This consisted of an undergarment or tunica and a mantle or toga, both of coarse linen . . ." (p. 48).

From *The Story of Wool:* "To a large degree, Roman dress, even during the classical era, was an adaptation of the woolen garments of their predecessors, the Etruscans of about 800 B.C. This consisted of an undergarment, or tunica, and a mantle, or toga, both made from woolen cloth" (p. 91).

B. From *The Story of Linen:* "The Flemish city of Bruges, which was founded by Charlemagne in 760 A.D., was soon busily engaged in exporting linen and in 1385 was hailed as 'the center of all commerce in Christendom.' It was the linen capital of the world and so remained during the middle ages" (p. 58).

From *The Story of Wool:* "Bruges, founded by Charlemagne in 760 A.D., was also busily engaged in manufacturing woolen cloth, and while in 1385, six hundred years later, it was hailed as 'the center of all commerce in Christendom,' yet it could, at least, modestly claim to be the wool capital of Europe during the Middle Ages" (pp. 132–133).

C. From *The Story of Linen:* ". . . until the 7th century, at which time cloth weaving [in England] was once again a growing industry and was mentioned by St. Oldheim [Aldhelm] as 'a home occupation for maidens.' He also speaks of 'webs of linen woven with shuttles filled with linen threads flying from side to side, forming a variety of images' " (p. 66).

From *The Story of Wool:* ". . . by the end of the 7th century, wool weaving was once again [in England] a thriving activity in homes of all ranks. Weaving of wool was especially recommended by St. Aldheim [Aldhelm] as 'an occupation for maidens.' Ladies of rank, even Saxon princesses, acquired so much skill in the art that another contemporary observed that 'webs woven, with shuttles flying from side to side, form a variety of images for woolen cloth' " (p. 153).

BENTLEY GLASS

EXPLORING OUR NATIONAL PARKS AND MONUMENTS. *By Devereux Butcher. Oxford University Press, New York.* 75 cents (paper). 160 pp.; ill. 1947.

This book, prepared by the Executive Secretary of the National Parks Association, is just what its title implies: a series of explorations of our National Parks and National Nature Monuments. Through this means the reader may explore 26 of the Parks and 38 of the Monuments. The Parks, arranged alphabetically, run from Acadia through Everglades, and the Monuments from Arches through Zion. The closing pages of the book discuss the need for these National Parks and Monuments, and the origin, present policy, and standards of the National Park Service, as well as nature reservations abroad. Three pages of Further Reading list an interesting bibliography of titles of value to the general reader.

The really striking feature of the book is the wealth of unusually fine and excellently reproduced photographs it contains. These portray landscapes, mountain formations, fauna and flora, fossils, cliff dwellings, glaciers, volcanoes, and many more subjects in a way to capture the imagination and stir enthusiasm. The descriptions of each Park and Monument in the text are brief but to the point.

This book should serve to arouse the interest of the general reader and particularly of students of the sciences in our National Parks and Monuments, as well as in all similar national and state preserves of wild life, forest, etc. It will be especially appreciated by anyone who is visiting, has visited, or plans to visit any of the places depicted. The book will whet the desire of its readers to tour our National Parks and Monuments.

ELLA THEA SMITH

THE BERKSHIRES: *The Purple Hills. Edited by Roderick Peattie. The Vanguard Press, New York.* $5.00. vi + 414 pp. + 16 plates; text ill. 1948.

Although this pleasantly readable book is one of the American Mountain series, the Berkshires scarcely justify their inclusion with the other mountain ranges of this country. Covering less than a thousand square miles in area, and dominated by few peaks, they form a twenty-mile wide plateau laced by numerous valleys gouged out by the ice sheet and deepened by subsequent rivers. Diminutive, therefore, in extent and height, the Berkshires have nonetheless come to mean many things to a variety of people. Culturally, they are important in having sheltered a number of New England's literary great, even as now they provide the setting for the Berkshire Music Festival. Historically, their importance lies in the barrier they once raised to the westward expansion of our country in its early days, and in the wealth of now-dead industries which stripped the hills of forests and iron ore. Scientifically, the hills have little claim to fame. The flora and fauna are neither striking nor extensive, and, geologically speaking, there are no unusual formations. Their fame, local though it is, lies in their picturesqueness and their ready accessibility. The Berkshire writers who have contributed their chapters to this book convey to the reader the hold that the hills have on them. In a number of instances this is overdone to a fault.

C. P. SWANSON

COLOUR PHOTOGRAPHY IN PRACTICE. *Third Edition. By D. A. Spencer. Pitman Publishing Corporation, New York and London.* $8.50. xx + 394 pp. + 19 plates; text ill. 1948.

Color photography is undoubtedly here to stay, and its future appears promising indeed. Over a period of years many processes have been designed to record color, have been tried and set aside only to be brought to light later with new improvements, while others have never quite reached the trial stage. Here is a book written by an eminent authority in the field of color photography, a book that gives the reader a wealth of information concerning the many phases of the subject which have led up to its present status. Extremely well written, it is also a book complete in all the essentials and up-to-the-minute developments, and it has been completely revised since the second edition was published in 1939. Along with the rewriting and assembling of this information, the author has included nineteen full-page color plates and nearly one hundred black-and-white and half-tone illustrations. The color plates dispersed throughout the text to illustrate the various processes being discussed are particularly appropriate as well as beautifully reproduced.

D. A. Spencer discusses Ansco Color, Agfacolor, Ektachrome, Ektacolor, Kodachrome, and Kodacolor of the modern color film processes, and in addition considers the color printing processes Printon, Dye Transfer, and Carbon, and the lesser known processes like Carbon Printing, Belcolor, Dufay Tissue, Chromotone, and Duxochrome. All of these methods are described with sufficient detail for one to use them without further information.

In addition to this complete and informative treatment of the subject, the author has taken time to begin each chapter with very appropriate quotations from *Alice in Wonderland*. This whimsical touch adds charm to a book that is far more than just a compilation of reference material. *Colour Photography in Practice* is recommended to both amateur and professional photographers.

JOHN S. SPURBECK

A TREASURY OF SCIENCE FICTION.

Edited with an Introduction by Groff Conklin. Crown Publishers, New York. $3.00. x + 517 pp. 1948. There is a fascination about science fiction that has won over many a scoffing reader. It is said that one of our most eminent American Nobel prize-winners is an ardent devotee, and it would be interesting to know what proportion of American scientists are readers of the type of story that began with Jules Verne and has seen prophecy after prophecy of the incredible future fulfilled. In fact, as one reads the better stories of this sort—and there is not the faintest doubt that Groff Conklin has collected a series of minor masterpieces—one is led to wonder how many of the authors are physicists, chemists, or biologists in disguise, giving free rein to fancy and yet building on a broad knowledge of present-day science and seeing whither the ever-expanding power of man through science is taking us. It becomes no joking matter when we recall that science fiction about the atomic bomb was so close to the truth that in the early period of the Manhattan Project it was feared that a serious leak of secret information must have occurred.

These stories are in the great American tradition, which gives little attention to the portrayal of character or to literary style. The plot's the thing. The several writers all seem to be masters of plot. They build upon suspense and have a fine feeling for a climax. Their models are Edgar Allen Poe, H. G. Wells, and Conan Doyle. You do not lay a story down after you have started to read it.

Particularly interesting is the trend the writers of science fiction seem to be following. Preoccupation with war is less complete, although a profound pessimism lurks in the background as the aftermath. More of the writers seem to be turning to biological themes, and thence to psychological and even sociological plots. The existence of undreamed of powers of enlargement of the human mind, and the hope of new forms of human organization that will supplant war with cooperative regulation seem to preoccupy the minds of some. Nearly all who touch on the social theme foresee a world-wide government of some sort, if one very different from anything contemplated today.

Story after story would make a perfect script for a thrilling movie. Why has Hollywood, with its penchant for fast action and for plot rather than character portrayal, missed its opportunity here?

BENTLEY GLASS

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